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S Y S T E M  
O F  
A N A T O M Y  
A N D  
P H Y S I O L O G Y;

FROM THE

LATEST and BEST AUTHORS.

ARRANGED,

AS NEARLY AS THE NATURE OF THE WORK WOULD ADMIT;

IN THE

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ANATOMY in the UNIVERSITY of EDINBURGH.

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# C O N T E N T S

## OF THE THIRD VOLUME.

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### P A R T VI.

#### Different Viscera.

<b>CHAP IV.</b> <i>The Pelvis,</i>	9
§ 6. <i>Menstruation,</i>	<i>ib.</i>
§ 7. <i>Of the Gravid Uterus,</i>	16
§ 8. <i>Of Conception,</i>	33
§ 9. <i>Nutrition, Growth, Life, and Death,</i>	75
<b>CHAP. V.</b> <i>Of the Arteries in general,</i>	84
§ 1. <i>Of the common Offices of the Arteries,</i>	93
§ 2. <i>Of the particular Arteries,</i>	110
<b>CHAP. VI.</b> <i>Of the Veins in general,</i>	161
§ 1. <i>Of the particular Veins,</i>	165
§ 2. <i>Veins of the Head and Neck,</i>	170
§ 3. <i>Veins of the Superior Extremities,</i>	177
§ 4. <i>Veins of the Thorax,</i>	181
§ 5. <i>Veins of the Chylopoietic and assistant         Chylopoietic Viscera,</i>	186
§ 6. <i>Veins of the Inferior Extremities,</i>	193
§ 7. <i>Veins of the Pelvis,</i>	197
§ 8. <i>Veins on the Back-part of the Abdomen         and Loins,</i>	200

#### Explanation of Tables XI. and XII.

<b>Tab. XI.</b> <i>Represents the Heart and Blood-vessels,</i>	203
<b>XII.</b> <i>Exhibits a Back-view of the Blood-vessels,</i>	205
<b>CHAP. VII.</b> <i>Of the Absorbent System,</i>	206
Sect. I. <i>Of the Absorbent System in general,</i>	208
Sect. II. <i>Particular Description of the Absorbent         System in the Human Body,</i>	212
	§ 1.

§ 1. Lymphatic Vessels of the Lower Extremities, . . . . .	212
§ 2. Absorbent Vessels of the Trunk, . . . . .	218
§ 3. Lymphatics of the Head and Neck, . . . . .	230
§ 4. Lymphatics of the Upper Extremities, . . . . .	234
Explanation of Tables XIII. and XIV. . . . .	235, 237
§ 5. Of the Chyle, . . . . .	234
<b>CHAP. VIII. Of the Properties of the Lymph, as observed by Mr Hewson, &amp;c. . . . .</b>	245
§ 1. Of the Secretion of the Lymph, . . . . .	250
§ 2. Of the supposed Absorption of the Lymph by the red Veins, . . . . .	255
§ 3. Of Absorption by the Lymphatic System, . . . . .	264

## P A R T VII.

## Of the Human Nerves.

<b>CHAP. I. Of the Nerves in general, . . . . .</b>	268
<b>CHAP. II. Of the Particular Nerves, . . . . .</b>	302
Explanation of Tables XV. and XVI. . . . .	330, 331

## Essay on Comparative Anatomy.

<i>Of Quadrupeds in general, . . . . .</i>	345
<i>The Anatomy of a Dog, . . . . .</i>	347
<i>The Anatomy of a Cow, . . . . .</i>	393
<i>Of Fowls in general, . . . . .</i>	405
<i>The Anatomy of a Cock, . . . . .</i>	409
<i>The Anatomy of a Carnivorous Bird, . . . . .</i>	435

## The Anatomy of Aqueous Animals.

I. <i>Amphibious, . . . . .</i>	436
II. <i>Fishes, . . . . .</i>	440
<i>The Anatomy of Insects, . . . . .</i>	452
<i>Of Worms, . . . . .</i>	454

## A S Y S T E M

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S Y S T E M  
O F  
A N A T O M Y,  
WITH THE  
P H Y S I O L O G Y.

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P A R T   V I .

Containing a DESCRIPTION of the  
D I F F E R E N T   V I S C E R A .

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C H A P   I V .

O f   t h e   P E L V I S .

§ 6. *Menstruation.*

T H E descriptions we have hitherto given of the female parts are in common to all ages of the sex; but about the 13th year, or somewhat later, nearly at the same time when semen begins to form itself in the male, there are likewise considerable changes produced in the female. For at this time the whole mass of blood begins to circulate with an increased force, the breasts swell out, and the pubes begins to be cloathed:

cloathed : at the same time the menses in some measure make their appearance by a common law of nature, although in different countries both the time and quantity of the flux is different.

But, before the menstrual flux, there are various symptoms excited in the loins, heavy pains, sometimes like colic pains, with an increased pulse, headaches ; and cutaneous pustules commonly precede, and a white juice commonly flows from the uterus. For now the fleecy vessels of the uterus, which in the state of the foetus were white, and transfused a sort of milk, as in the young girl they transfused a serous liquor, do now begin to swell with blood ; the red parts of which are deposited through the vessels into the cavity of the uterus. This continues some days, while in the mean time the first troublesome symptoms abate, and the uterine vessels, gradually contracting their openings, again distil only a little serous moisture as before. But then the same efforts return again at uncertain intervals in tender virgins ; till at length, by degrees, they keep near to the end of the fourth week ; at which time follows the flux of blood, as before, which is periodical- ly continued till between the 45th and 50th year ; though the diet, country, constitution, and way of life, cause a great variation in this discharge. Pregnancy commonly produces a temporary stoppage of the menses.

This discharge of blood from the vessels of the uterus itself, is demonstrated by inspection in women who have died in the midst of their courses ; and in living women, having an inversion of the uterus, the blood has been seen plainly to distil from the open orifices : in others, in whom, when the menses have been deficient, the uterus has appeared full of concreted blood. It also appears from the nature of the uterus it- self full of soft spongy vessels, compared with the thin, callous, by no means fleecy, and almost bloodless sub- stance of the vagina. That this is good blood in an healthy

healthy woman, appears both from the foregoing and innumerable other observations. Nevertheless nothing hinders the blood from being sent forth through the vagina, as in other cases it is through the intestinum rectum, and in short through the remotest parts of the body.

Since none but the human species are properly subject to this menstrual flux of blood (although there are some animals who, at the time of their vernal copulation, distil a small quantity of blood from their genitals), and since the body of the male is always free from the like discharge; it has been a great inquiry in all ages, what should be the cause of this sanguine excretion peculiar to the fair sex? To this effect the attraction of the moon, which is known to raise the tides of the sea, has been accused in all ages; others have referred it to a sharp stimulating humour, secreted in the genital parts themselves, the same which is the cause of the venereal disease. But if the moon was the parent of this effect, it would appear in all women at the same time; which is contrary to experience, since there is never a day in which there are not many women seized with this flux; nor are there fewer in the decrease than the increase of the moon. As to any sharp ferment seated in the uterus or its parts, it will be always inquired for in vain; where there are none but mild mucous juices, and where venery, which expels all those juices, neither increases nor lessens the menstrual flux; and women deny that, during the time of their menses, they have any increased desire of venery; seeing at that time most of the parts are rather pained and languid; and the seat of venereal pleasure is rather in the entrance of the pudendum than in the uterus, from which last the menses flow. But, lastly, that the menstrual blood is forced out by some cause exciting the motion of the blood against the vessels, appears from hence, that, by a retention, the courses have been known to break through all the other organs of the body,

body, where no vellicating ferment could be seated, so as to burst open the vessels of each organ ; and that the effect produced by the retention of the blood, is not confined to those parts which pour out the venereal humour.

Nature has, in general, given women a more delicate body ; and solids that are less elastic ; their muscles are also smaller, with a greater quantity of fat interposed both betwixt them and their fibres ; the bones too are slenderer, and their surfaces have fewer processes and asperities. Moreover, the pelvis of the female is, in all its dimensions, larger ; the ossa ilia spread farther from each other ; and the os sacrum recedes more backward from the bones of the pubes, while the ossa ischii depart more from each other below : however, the angle in which the bones of the pubes meet together to form an arch, is in the female remarkably more large ; which differences are confirmed by the observations of the great anatomists ; and from necessity itself, which requires a greater space for a greater number of viscera in the pelvis. Moreover, the uterine arteries are considerably large, more so than in men ; and have a greater proportion of light, with respect to the thickness of their coats : but the uterine veins are, in proportion, less than in men ; and of a more firm resisting texture, than in other parts of the body. From hence it follows, that the blood, brought by the arterial trunk to the womb, by passing from a weaker artery into a narrow and more resisting vein, will meet with a more difficult return, and consequently distend the uterine vessels.

The female infant new born has her lower limbs very small ; and the greater part of the blood, belonging to the iliac arteries, goes to the umbilicals, sending down only a small portion to the pelvis. Hence the pelvis is small, and but little concave ; so that the bladder and uterus itself, with the ovaries, project beyond the rim of the pelvis. But when the fœtus is born,  
and

and the umbilical artery is tied, all the blood of the iliac artery descends to the pelvis and lower limbs, which of course grow larger, and the pelvis spreads wider and deeper: so that, by degrees, the womb and bladder are received into its cavity, without being any longer compressed by the intestines and peritoneum, when the abdominal muscles press upon the lower parts of the abdomen. When now the increase is perfect, or next to it, then in general we find those arteries of the uterus largest, which in the foetus were least, and easily injected with wax; and all things are changed in such a manner, that the hemorrhoidal artery is now in place of the hypogastric, when formerly the umbilical had been the trunk of that artery. More blood, therefore, at that time comes into the uterus, vagina, and clitoris, than formerly used to do.

At the same time, when the growth of the body begins considerably to diminish, and the blood, finding easy admittance into the completed viscera, is prepared in a greater quantity, the appetite being now very sharp, in both sexes, a plethora consequently follows. In the male, it vents itself frequently by the nose, from the exhaling vessels of the pituitary membrane being dilated to so great a degree without a rupture, as to let the red blood distil through them; and now the semen first begins to be secreted, and the beard to grow. But in the female, the same plethora finds a more easy vent downward; being that way directed partly by the weight of the blood itself, to the uterine vessels now much enlarged, of a soft fleecy fabric, seated in a loose hollow part, with a great deal of cellular fabric interspersed, which is very yielding and succulent, as we observe in the womb: for these causes, the vessels being easily distendible, the blood finds a more easy passage through the very soft fleecy exhaling vessels, which open into the cavity of the uterus, as being there less resisted than in its return by the veins, or in taking a course through any other part; because, in females, we

observe the arteries of the head are both smaller in proportion, and of a more firm resisting texture. The return of the same is therefore more slow, both because the flexures of the arteries, from the increased afflux of the blood, become more serpentine and fit for retarding the blood's motion, and likewise because it now returns with difficulty through the veins. The blood is, therefore, first collected in the vessels of the uterus, which at this time, by repeated dissections, are observed to be swelled; next it is accumulated in the arteries of the loins and the aorta itself, which, urging on a new torrent of blood, augments the force, so far as to discharge the red blood into the serous vessels, which at first transmit an increased quantity of warm mucus, afterward a reddish coloured serum; and by suffering a greater distention, they at last emit the red blood itself. The same greater impulse of blood, determined to the genital parts, drives out the hitherto latent hairs, increases the bulk of the clitoris, dilates the cavernous plexus of the vagina, and whets the female appetite to venery. Accordingly we find, that the quantity of the menstrual flux, and the earliness of their appearance, are promoted by every thing that either increases the quantity or momentum of the blood with respect to the body in general, or which direct the course of the blood more particularly towards the uterus; such as joy, lust, bathing of the feet, a rich diet, warm air, and lively temperament of body. It is diminished by those things which lessen plethora and the motion of the blood, as want, grief, cold air, sloth, and antecedent diseases.

When five or six ounces of blood have been thus evacuated, the unloaded arteries now exert a greater force of elasticity, and, like all arteries that have been overcharged with blood, contract themselves by degrees to a less diameter, so as at length to give passage only to the former thin exhaling moisture; but the plethora or quantity of blood, being again increased from the same

same causes, a like discharge will always more easily ensue through the vessels of the uterus, after they have been once thus opened, than through any other part. Nor is there any occasion to perplex ourselves about the cause, why this periodical discharge is, for the most part, nearly regular or menstrual; for this depends upon the proportion of the quantity and momentum of the blood daily collected, together with the resistance of the uterus, which is to yield again gradually to the first course. Therefore this critical discharge of blood never waits for the interval of a month, but flows sooner or later, according as the greater quantity of blood in plethoric women is determined, by lust or other causes, towards the uterus. Finally, they cease to flow altogether, when the uterus, like all the other solid parts of the body, has acquired so great a degree of hardness and resistance, as cannot be overcome by the declining force of the heart and arteries, by which the blood and juices are driven on through all the vessels. This increased hardness in the old uterus is so remarkable in the arteries and ovaries, that it easily discovers itself both to the knife and the injections of the anatomist. But, in general, brute animals have no menses; because, in them, the womb is in a manner rather membranous than fleshy, with very firm or resisting vessels, which, with the difference of their posture, never permit a natural hemorrhagy from the nostrils or other parts. They are wanting in men, because in that sex there is no spongy organ fit for retaining the blood; and likewise because the arteries of the pelvis are both harder and less, in proportion, than the veins; and thus the impetus of the blood in the lower limbs is turned away, whose vessels in men are larger, as those of the pelvis are smaller.

It will, perhaps, be demanded, why the breasts swell out at the same time with the approach of the menses? We are to observe, that the breasts have many particulars in their fabric, common to that of the uterus; as

appears from the secretion of the milk in them after the birth of the foetus, which increases or diminishes in proportion as the lochial flux is either increased or diminished ; from the similitude of the serous liquor, like whey, found in the uterus, so as to resemble milk, in those who do not suckle their children, being of a thin and white consistence, appearing very evidently in brute animals ; also from the turgescence or erection of the papillæ or nipples of the breast by friction, analogous to the erection of the clitoris. Therefore, the same causes which distend the vessels of the uterus, likewise determine the blood more plentifully to the breasts ; the consequence of which is an increased bulk and turgescence of the conglomerate glandules and cellular fabric which compose the breasts.

#### § 7. *Of the Gravid Uterus.*

##### ART. I. STRUCTURE of the OVUM in early GESTATION,

WHEN the rudiments of the foetus get into the uterus, impregnation is said to take place. The ovum, soon after its introduction, adheres to some part of the internal surface of the uterus : at first it appears like a small vesicle, slightly attached ; and gradually increases in bulk, till it apparently comes in contact with the whole cavity of the uterus.

The embryo, with umbilical cord, membranes, and waters, in early gestation, constitute the ovum ; which then appears like a thickened fleshy mass, the more external parts, which are afterwards separate and distinct, being blended in such a manner that they cannot be readily distinguished.

In the progress of gestation every part of the ovum becomes more distinct ; and then a thick vascular part on the outside of the chorion, called *placenta*, can be readily perceived.

The external membranous part of the ovum is originally

ginally composed of three coats : the internal lamella, or that next the fœtus, is called *amnios*; the next is the *true chorion*; and the external is called the *false* or *spongy chorion*. But it is supposed to derive an extraordinary lamella immediately from the uterus, which constitutes the external covering of the ovum. This production, which is supposed to be entirely formed by a continuation of the internal membrane of the uterus, is at first loosely spread over the ovum, and afterwards comes in contact with the false chorion. These two lamellæ, which form the external vascular surface of the ovum, are much thicker than the internal membranes of the true chorion and amnios; and the proportion which they bear to the other parts is so great, that, in early conception, the mass of the ovum is chiefly composed of them. Dr Ruysch called this exterior coat the *tunica filamentosa*; more modern authors, the *false* or *spongy chorion*. But Dr Hunter has found the spongy chorion to consist of two distinct layers : that which lines the uterus he styles *membrana caducæ* or *decidua*, because it is cast off after delivery ; the portion which covers the ovum, *decidua reflexa*, because it is reflected from the uterus upon the ovum. The membrana decidua is perforated with three foramina, viz. two small ones, corresponding with the insertion of the tubes at the fundus uteri ; and a larger ragged perforation opposite to the orificium uteri.

Thus, according to Dr Hunter, the embryo, on its first formation in the ovum, and the fœtus during the whole time of gestation, is inclosed in four membranes, viz. the double, false, or spongy chorion, called *membrana decidua*, and *decidua reflexa*; the true chorion, and the amnios, which include a fluid called the *liquor amnii*, in which the embryo floats.

The true chorion and the amnios are very thin transparent membranes. The decidua, and *decidua reflexa*, differ in appearance, and seem to resemble those inorganic substances which connect inflamed viscera, and have

have been considered by some late writers as being composed of inspissated coagulated lymph.

Between the amnios and chorion, a quantity of gelatinous fluid is contained in the early months; and a small bag, or white speck, is then observed on the amnion, near the insertion of the umbilical cord. It is filled with a white liquor, of a thick milky consistence; and is called *vesicula umbilicalis*, *vesicula alba* or *lactea*: it communicates with the umbilical cord by a small funis, which is made up of an artery and vein. This vesicle, and duct or tube leading from it, are only conspicuous in the early months; and afterwards become transparent, and of consequence invisible. Their use is not yet understood.

Though the bag, or external parts of the conception, at first form a large proportion of the ovum in comparison of the embryo or foetus, in advanced gestation the proportions are reversed. Thus an ovum between the eighth and ninth week after conception, is nearly about the size of a hen's egg, while the embryo scarcely exceeds the weight of a scruple: at three months, the former increases beyond the magnitude of a goose's egg, the weight above eight ounces; but the foetus does not then amount to three ounces: at six months, the foetus weighs twelve or thirteen ounces, and the placenta and membranes only seven or eight: at eight months, the foetus weighs between four and five pounds, the secundines little more than one pound: at birth, the foetus, according to Dr Hunter, weighs from five to eight pounds; and this agrees nearly with the observation of Dr Wrisberg: but the placenta seldom increases much in bulk from between the seventh and eighth month.

Having described the ovum in early gestation, we shall next take a view of the germ; trace the progress of the embryo and foetus; then resume the subject of the ovum, to explain the structure of the membranes, placenta,

centa, &c. in advanced gestation, and point out the most remarkable changes which the uterus suffers during impregnation.

## ART. II. EVOLUTION OF THE FOETUS.

THERE can be little doubt that all the parts of an animal exist completely in the germ, though their extreme minuteness and fluidity for some time conceal them from our sight. In a state of progression, some of them are much earlier conspicuous than others.

The embryo, in its original state, seems to contain, in a small scale, all the other parts which are afterwards to be progressively evolved. First the heart and liver, then the brain and spinal medulla, become conspicuous: for the spine or carina of the embryo is formed some time before any vestige of extremities begin to sprout. The encephalon, or head, and its appendages, first appear; then the thoracic viscera; next, the abdominal: at length the extremities gradually shoot out; the superior first, then the inferior; till the whole is evolved.

As soon as the embryo has acquired sufficient consistence to be the subject of any observation, a little moving point, which is the heart, discovers itself. Nothing, however, but general circumstances relating to the particular order and progress of the successive germination or evolution of the viscera, extremities, vascular system, and other parts of the human foetus, can be ascertained, as it is beyond the power of anatomical investigation.

It is also exceedingly difficult to determine the age or proportional growth of the foetus. The judgment we form will be liable to considerable variation: 1st, From the uncertainty of fixing the period of pregnancy; 2dly, From the difference of a foetus of the same age in different women, and in the same woman in different pregnancies; and, lastly, Because the foetus is often retained

retained *in utero* for some time after the extinction of its life.

The progress of the foetus appears to be much quicker in the early than latter months : but the proportional increase is attended with difficulty in the calculation ; for this, among other reasons, that we have not an opportunity of knowing the magnitude or weight of the same foetus in different months. It will also, probably, be materially influenced by the health, constitution, and mode of life, of the parent.

A foetus of four weeks, is near the size of a common fly ; it is soft, mucilaginous, seems to hang by its belly, and its bowels are only covered by a transparent membrane. At six weeks, the consistence is still gelatinous, the size about that of a small bee, the head larger than the rest of the body, and the extremities then begin to shoot out. At eight weeks, it is about the size of a field bean, and the extremities project a little from the body. At twelve weeks, it is near three inches long, and its formation pretty distinct. At four months, the foetus measures above five inches ; at five months, between six and seven inches ; at six months, the foetus is perfect in all its external parts, and commonly in length about eight, or between eight and nine inches ; at seven months, it is between eleven and twelve inches ; at eight months about fourteen or fifteen inches ; and at full time, from eighteen to twenty-two and twenty-three inches. But these calculations, for the above reasons, must be very uncertain.

### ART. III. CONTENTS of the GRAVID UTERUS in advanced GESTATION.

THESE consist of the foetus, umbilical cord, placenta, membranes, and contained fluid. We have already traced the progress of the foetus ; and shall proceed to describe the other parts of the ovum in advanced gestation, as just now enumerated.

*Umbilical*

*Umbilical cord.* The foetus is connected to the placenta by the umbilical cord or navel-string; which may be defined, a long vascular rope, composed of two arteries and a vein, covered with coats derived from the membranes, and distended with a quantity of viscid gelatinous substance, to which the bulk of the cord is chiefly owing.

The cord always arises from the centre of the child's belly, but its point of insertion in the cake is variable. If the placenta adhere to the fundus, or is fixed over the mouth of the uterus, it is then of a round form, and the cord arises from its middle; but if the placenta adhere elsewhere, the cord is inserted nearer its edge. Its shape is seldom quite cylindrical; and its vessels are sometimes twisted or coiled, sometimes formed into longitudinal fulci. Its diameter is commonly about the thickness of an ordinary finger, and its length sufficient to admit the birth of the child with safety, though the placenta should adhere at the fundus uteri. In length and thickness, however, it is liable to considerable variation. The extremity next the foetus is generally strongest; and is somewhat weaker and more slender next the placenta, according to its place of insertion; which, though commonly not far from the centre, is sometimes towards the very edge. This suggests an important advice to practitioners, to be cautious of pulling the rope to extract the placenta when they feel the sensation of its splitting as it were into two divisions, which will proportionally weaken its resistance, and render it liable to be ruptured with a very slight degree of force in pulling. The use of the cord is to connect the foetus to the cake, to convey the nutritious fluid from the mother to the child, and to return what is not employed.

*Placenta.* The placenta, cake, or after-birth, is a thick, soft, vascular mass, connected to the uterus on one side, and to the umbilical cord on the other. It differs in shape and size; it is thickest at the centre,  
and

and gradually becomes thinner towards the edges, where the membranes go off all round, making a complete bag or involucrum to surround the waters, funis, and child.

Its substance is chiefly vascular, and probably in some degree glandular. The ramifications of the vessels are very minute, which are unravelled by maceration, and, when injected, exhibit a most beautiful appearance resembling the bushy tops of a tree. It has an external convex, and an internal concave, surface. The former is divided into a number of small lobes and fissures, by means of which its adhesion to the uterus is more firmly secured. This lobulated appearance is most remarkable when the cake has been rashly separated from the uterus ; for the membrana decidua, or connecting membrane between it and the uterus, being then torn, the most violent and alarming haemorrhagies frequently ensue.

The internal concave surface of the placenta is in contact with the chorion, and that with the amnion. From its internal substance arise innumerable ramifications of veins and arteries, which inosculate and anastomose with one another ; and at last the different branches unite, and form the funis umbilicalis.

The after-birth adheres to every part of the internal surface of the uterus, as at the posterior and anterior, superior and lateral parts ; and sometimes, though more rarely, part of the cake extends over the orificium uteri ; from whence, when the orifice begins to dilate, the most frightful and dangerous floodings arise. But the most common place of attachment of the cake is from the superior part of the cervix to the fundus.

Twins, triplets, &c. have their placenta, sometimes separate, and sometimes adhering together. When the placentæ adhere, they have generally the chorion in common ; but each foetus has its distinct amnion. They are commonly joined together, either by an intervening membrane, or by the surfaces being contiguous.

guous to one another; and sometimes the vessels of the one cake anastomose with those of the other.

The human placenta, according to Dr Hunter, and others who believe that the child is nourished by a secreted liquor, is composed of two distinct systems of parts, a spongy or cellular, and a vascular substance; the spongy or cellular part, formed by the *decidua*, being derived from the mother, the more internal vascular part belonging entirely to the foetus; but, according to those who are of opinion that a real circulation is carried on between the mother and child, the placenta is chiefly composed of vessels which are connected by the common cellular substance.

**MEMBRANES.** These consist, externally, of two layers of the spongy chorion, called *decidua*, and *decidua reflexa*; internally, of the true chorion and the amnion. They form a pretty strong bag, commencing at the edge of the cake, going round the whole circumference, and lining the internal surface of the womb. When separated from the uterus, this membranous bag is slender and yielding, and its texture readily destroyed by the impulse of the contained fluid, the pressure of the child, or of the finger in touching; but in its natural state, while it lines the womb, and is in close contact with its surface, the membranous bag is so tough and strong as to give a considerable degree of resistance. It is also strengthened in proportion to the different layers of which it is composed, whose structure we shall proceed to explain more particularly.

1. The *membrana decidua*, or that lamella of the spongy false chorion which is in immediate contact with the uterus, is originally very thick and spongy, and exceedingly vascular, particularly where it approaches the placenta. At first, there is a small intervening space between it and the ovum, which is filled with a quantity of gelatinous substance. It gradually becomes more and more attenuated by stretching, and

approaches

approaches nearer to the decidua reflexa ; and about the fifth month the two layers come in contact, and adhere so as to become apparently one membrane.

2. *Decidua reflexa.* In its structure and appearance it is similar to the former, being rough, fleecy, and vascular, on its external surface. In advanced gestation, it adheres intimately to the former membrane, and is with difficulty separated from it.

The decidua reflexa becomes thicker and more vascular as it approaches the placenta, and is then blended with its substance, constituting the cellular or maternal part of the cake, as it is termed by Dr Hunter. The other or more internal part belongs to the foetus, and is styled the *fœtal* part of the placenta.

The double decidua is opaque in comparison of the other membrane ; the blood-vessels are derived from the uterus, and can be readily traced into it. Dr Hunter supposes that the double decidua lines the uterus nearly in the same manner as the peritonæum does the cavity of the abdomen, and that the ovum is inclosed within its duplicature as within a double night-cap. On this supposition the ovum must be placed on the outside of this membrane, which is not very readily to be comprehended ; unless we adopt Signior Scarpa's opinion already mentioned, and suppose it to be originally entirely composed of an inspissated coagulable lymph.

3. The *true chorion*, or that connected with the amnion, is the firmest, smoothest, and most transparent of all the membranes, except the amnios ; and, when separated from it, has a considerable degree of transparency. It adheres pretty closely to the internal surface of the cake, which it covers immediately under the amnios, and gives also a coat to the umbilical cord. It is connected to the amnion by means of a gelatinous substance, and is easily separated from it.

4. The *amnion*, or internal membrane, forms the external coat of the umbilical cord. This internal la-

mella

mella of the membranous bag is the most thin, attenuated, and transparent of the whole ; and its vessels are so delicate, that they can hardly be discovered ; their diameters are so small as to be incapable in their natural state of admitting globules of red blood. It is, however, firmer and stronger than the chorion, and gives the greatest resistance in the breaking of the membranes.

The small bag, called *vesicula umbilicalis*, formerly described, and only conspicuous in the early months from its situation, is placed between the amnion and chorion, near the attachment of the cord ; and, from the colour of its contents, has been mistaken for the urachus : but there is no allantois in the human subject.

The allantois in quadrupeds is an oblong membranous sac, or pouch, placed between the chorion and amnion. This membrane communicates with the urachus, which in brutes is open, and transmits the urine from the bladder to the allantois.

5. The *waters* are contained within the amnion, and are called the *liquor amnii*. They are purest, clearest, and most limpid in the first months ; acquiring a colour, and becoming somewhat ropy, towards the latter end. They vary in different subjects, both in regard to consistence and quantity ; and, after a certain period, they proportionally diminish as the woman advances in her pregnancy. This liquor does not, in any respect, resemble the white of an egg ; it is generally saltish, and therefore unfit for the nutrition of the child ; some of it may perhaps be absorbed by the foetus, but the child is chiefly nourished by the navel-string. In the early months, the organs are not fit for swallowing ; and monsters are sometimes born alive, where such organs are altogether wanting.

Water is sometimes collected between the chorion and amnion, or between the lamellæ of the chorion. This is called the *false water*. It is generally in much

smaller quantity than the true water; and, without detriment to the woman, may flow at any time of pregnancy.

Having described the contents of the gravid uterus, let us consider the changes which that organ suffers during the progress of gestation, and explain the manner of circulation between the parent and foetus, and within the body of the foetus; after which we shall enumerate the most remarkable peculiarities of the nonnatus.

#### ART. IV. CHANGES of the UTERINE SYSTEM from IMPREGNATION.

THOUGH the uterus gradually increases in size from the moment of conception till full time, and although its distention is proportioned to that of the ovum, with regard to its contents, it is, strictly speaking, never completely distended; for in early gestation, they are entirely confined to the fundus; and, at full time, the finger can be passed for some way within the orificium uteri without touching any part of the membranes. Again, though the capacity of the uterus increases, yet it is not mechanically stretched, for the thickness of its sides does not diminish. The increased size seems, therefore, to depend on a proportionable quantity of fluids sent to that part, nearly in the same way the skin of a child, though it suffers so great distention, does not become thinner, but preserves its usual thickness.

This is proved from several instances of extra-uterine foetuses, where the uterus, though there were no contents, was nearly of the same size, from the additional quantity of fluids transmitted, as if the ovum had been contained within its cavity. Bochmerus relates the same circumstance, without attempting to explain it, in the history of a case of extra-uterine conception in the fifth month. The uterus is painted of a considerable size, though the foetus was contained in the ovary.

The

The gravid uterus is of different size in different women; and will vary according to the bulk of the foetus and involucra. The situation also varies according to the increase of its contents, and the position of the body. For the first two or three months, the cavity of the fundus is triangular as before impregnation; but as the uterus stretches, it gradually acquires a more rounded form. In general, the uterus never rises directly upwards, but inclines a little obliquely; most commonly to the right side: its position is never, however, so oblique as to prove the sole cause either of preventing or retarding delivery.

Though considerable changes are occasioned by the gradual distention of the uterus, it is difficult to judge of pregnancy from appearances in the early months. For the first three months, the os tincæ feels smooth and even, and its orifice is nearly as small as in the virgin state. When any difference can be perceived, it will consist in the increased length of the projecting tubercle of the uterus, and the shortening of the vagina from the descent of the fundus uteri through the pelvis. This change in the position of the uterus, by which the projecting tubercle appears to be lengthened, and the vagina proportionally shortened, chiefly happens from the third to the fifth month. From this period the cervix begins to stretch and be distended, first at the upper part; and then the os tincæ begins also to suffer considerable changes in its figure and appearance. The tubercle shortens, and the orifice expands: but during the whole term of gestation, the mouth of the uterus is strongly cemented with aropy mucus, which lines it and the cervix, and begins to be discharged on the approach of labour. In the last weeks, when the cervix uteri is completely distended, the uterine orifice begins to form an elliptical tube, instead of a fissure; and sometimes, especially when the parietes of the abdomen are relaxed by repeated pregnancy, disappears entirely, and is without the reach of the finger in touching.

ing. Hence the os uteri is not placed in the direction of the axis of the womb, as has generally been supposed.

The progressive increase of the abdominal tumor, from the stretching of the fundus, affords a more decisive mark of the existence and period of pregnancy than any others; and the progress is nearly as follows.

About the fourth, or between the fourth and fifth month, the fundus uteri begins to rise above the pubes or brim of the pelvis, and the cervix to be somewhat distended. In the fifth month, the belly swells like a ball with the skin tense, the fundus extends about half way between the pubes and navel, and the neck is sensibly shortened. In the seventh month, the fundus, or superior part of the uterine tumor, advances as far as the umbilicus; and the cervix is then nearly three-fourths distended. In the eighth, it reaches mid-way between the navel and scrofula cordis; and in the ninth, to the scrofula itself, the neck then being entirely distended; which, with the os tincæ, become the weakest parts of the uterus. Thus at full time the uterus occupies all the umbilical and hypogastric regions: its shape is almost pyriform, that is, more rounded above than below, and having a stricture on that part which is surrounded by the brim of the pelvis.

During the progress of distention, the substance of the uterus becomes much looser, of a softer texture, and more vascular, than before conception; and the diameter of its veins is so much enlarged, that they have acquired the name of *sinuses*. They observe a more direct course than the arteries, which run in a serpentine manner through its whole substance, and anastomose with one another, particularly at that part where the placenta is attached: It is in this part also that the vascular structure is most conspicuous.

The arteries, according to Dr Hunter, &c. pass from the uterus, through the decidua, into cells in the placenta and veins, corresponding with the arteries, return

the

the blood to the mother. According to other authors, the arteries end partly in the veins of the mother, and partly in the veins of the child.

The muscular structure of the gravid uterus is extremely difficult to be traced with any exactness in the unimpregnated state; but in the gravid uterus they appear more distinctly. In the wombs of women who die in labour, or soon after delivery, fibres running in various directions are observable more or less circular. These seem to arise from three distinct origins, viz. from the place where the placenta adheres, and from the aperture or orifice of each of the tubes: but it is almost impossible to demonstrate regular plans of fibres continued any length without interruption.

The appendages of the uterus suffer also considerable changes; for the tubes, ovaries, and ligaments, gradually go off below the fundus as it stretches, and at full time are almost entirely obliterated. At full time, especially in a first pregnancy, when the womb rises higher than in subsequent impregnations, the ligamenta rotunda are considerably stretched; and to this cause those pains are probably owing which strike from the belly downwards in the direction of these vascular ropes, which are often very painful and distressing towards the latter end of gestation. Again, as the uterus, which is chiefly enlarged towards the fundus, at full time stretches into the cavity of the abdomen without any support, leaving the broad ligaments below the most bulky part, we can readily see, that by pulling at the umbilical cord to deliver the placenta, before the uterus is sufficiently contracted, the fundus may be pulled down through the mouth of the womb, even though no great violence be employed. This is styled the *inversion* of the uterus; and is a very dreadful, and generally fatal, accident. It is the consequence only of ignorance or temerity; and can scarcely happen but from violence, or from an officious intrusion on the work of nature, by pulling at the rope while the woman

woman is faint or languid, and the uterus in a state of atony.

In some rare instances, the force of labour which propels the child where the cord is short naturally, or rendered so by circumvolutions round the body of the child, may, when the placenta adheres to the fundus uteri, bring it down so near the os tincæ, that little force would afterwards be sufficient to complete the inversion. This suggests a precaution, that in the above circumstances, if strong labour-pains should continue, or a constant bearing down ensue, after the delivery of the child, the practice of pulling by the cord should be carefully avoided, and the hand of the operator be prudently conducted within the uterus, to separate the adhesion of the cake, and guard against the hazard of inversion.

The ovaria also suffer some change from pregnancy.

A roundish figure of a yellow colour appears in one of them, called by anatomists the *corpus luteum*; and in cases of twins, a corpus luteum often appears in each ovary. It was imagined to be the calyx ovi; and is observed to be a gland from whence the female fluid or germ is ejected. In early gestation, this cicatrix is most conspicuous, when a cavity is obvious, which afterwards collapses.

If the ovary be injected in the latter months, the corpus luteum will appear to be composed chiefly of vessels. A portion of it, however, in the centre, will not be filled; from which it is, with some reason, suspected that it is a cavity, or that it contains a substance not yet organized.

#### ART. V. CIRCULATION in the FOETUS.

THE circulation in the substance of the placenta, notwithstanding what has been said by different authors, seems to be not yet fully understood; but of one thing we are certain, that the blood passes directly from the placenta

placenta into the umbilical vein ; which, running along the funis, perforates the belly of the foetus, and enters under the liver, where it divides into two branches, nearly at half a right angle. One of these branches, called the *ductus venosus*, carries part of the blood to the left branch of the *vena cava hepatis*, and from that to the *vena cava*. The other carries the rest to the *vena portarum* ; where, after circulating through the liver, it also gets into the *vena cava*, and so to the heart : but the circulation here is carried on without any necessity for the lungs being dilated. For foetuses have an oval hole open between the two auricles of the heart, and a large communicating canal, called *canalis arteriosus*, going between the pulmonary artery and aorta ; which two passages allow the rest of this circulating fluid, that returns by the *cava superior*, to be transmitted to the aorta, without passing through the lungs.

The blood is returned from the foetus by the *arteriae umbilicales*, which take their rise sometimes from the trunk of the aorta, but commonly from the iliac arteries of the foetus ; and, running by the external sides of the bladder, ascend to go out at the navel.

#### ART. VI. POSITION of the FOETUS in UTERO.

THE foetus is commodiously adapted to the cavity of the uterus, and describes an oblong or oval figure ; its several parts being collected together in such a manner as to occupy the least possible space. The spine is rounded, the head reclines forward towards the knees, which are drawn up to the belly, while the heels are drawn backwards towards the breech, and the hands and arms are folded round the knees and legs. The head of the child is generally downwards. This does not proceed, as was commonly alleged, from the funis not being exactly in the middle of the child's body, for it is not suspended by the funis : the reason is, because the superior parts are much larger and heavier

in proportion than the inferior. When other parts present, it seems owing to the motion of the child altering its figure when the waters are much diminished in quantity, or to circumvolutions of the cord: when the position is once altered, it becomes confined or locked in the uterus, and cannot easily resume its original posture.

As the figure of the foetus is oval, and the head naturally falls to the most depending part of the uterus, the vertex generally points to the os tincæ, with the ears diagonally in the pelvis between the pubes and sacrum. The foetus is mechanically disposed to assume this position from its peculiar figure and construction, particularly by the bulk of the head and articulation with the neck, by the action of its muscles, and by the shape and construction of the cavity in which it is contained.

#### ART. VII. PECULIARITIES OF THE FOETUS.

THE foetus, both in external figure and internal structure, differs materially, in many striking circumstances, from the adult. It is sufficient for our present purpose to mention a few particulars.

The head is very large in proportion to the rest of the body: the cranial bones are soft and yielding, and the sutures not yet united, so that the bulk of the head may be diminished in every direction, and its passage consequently be rendered more commodious. The bones of the trunk and extremities, and all the articulations, are also remarkably flexible. All the apophyses are epiphyses; even the heads and condyles and brims of cavities, instead of bone, are of a soft cartilaginous consistence.

The brain, spinal marrow, and whole glandular as well as nervous and sanguiferous systems, are considerably larger in proportion in the foetus than in the adult. It has a gland situated in the fore-part of the chest between

tween the laminæ of the mediastinum, called the *thy-mus*. The liver and kidneys are much larger in proportion ; and the latter are divided into a number of small lobes, as in the brute.

The foetus also differs in several circumstances from a child who has breathed.

The cavity of the thorax is less in proportion than after respiration. The lungs are smaller, more compact, of a red colour like the liver, and will sink in water ; but putrefaction, and a particular emphysema, as in diseases of cattle, and blowing into them, will make them swim : which should prevent us from hastily determining, from this circumstance, whether a child has breathed or not ; which we are often called on to do. Neither does their sinking prove that the child never breathed ; for a child may die, or be strangled in the birth, or immediately after, before the lungs are fully inflated.

The arterial and venous systems are also different from that of the child. Hence the difference in the manner of circulation already taken notice of.

#### § 8. *Of Conception.*

THIS is a very arduous investigation, as we propose to discover the changes which take place in the inward parts of woman, when a new creature begins to germinate, who is, in proper time, to be exposed to light. We shall relate, in the first place, therefore, those things which experience shows to be true ; and then add those hypotheses by which learned men have endeavoured to supply such things as are not evident from the subject itself. How few things are ascertained on this subject, and how difficultly they are ascertained, daily experience shows.

That some light may be thrown on such a dark subject, we shall begin with the most simple animals, and afterwards take notice of what nature has added in others

thers whose fabric is more compounded. The smallest animals, then, which have very few or no limbs, the least distinction of parts, the shortest life, the vital functions both few and very similar to one another; these animals bring forth young ones like themselves, with no distinction of sexes, as all of them are fruitful, and none imparts fecundity to the rest. Some of them exclude their young whom they have conceived in their body, through a certain cleft; from others, some limbs fall off, which are completed into animals of a kind similar to those from which they have fallen off. This kind of generation is extended very wide, and comprehends the greater part of animal life.

The next to these, which are a little more compounded, all bring forth their young; yet in such a manner, that in their bodies is generated a certain particle peculiar to themselves, dissimilar to the whole animal, and contained in some involucra, within which lies the animalcule that is afterwards to become similar to that within which it is produced; this is commonly called an *egg*. A great part of these animals is immoveable.

The animals which follow are not indeed numerous, but have both eggs, and male semen besides; so that both sexes are joined in the same animal. But we call it *male semen*, because it is necessary for sprinkling the eggs in order to render them prolific, although it never grows alone into a new animal. In this class, therefore, a juice is prepared by its own proper organs, which is likewise poured on the eggs through organs proper to itself, but different from the former, in order to generation.

Those animals are much more numerous which have both a male juice and female eggs; yet such as cannot fecundate themselves, but require true coition. For two animals of this kind agree in the work of fecundation, in such a manner, that each impregnates the other with its male organs, and again suffers itself to be

be impregnated in its female ones by the male parts of the other.

And now the nature of animals approaches nearer and nearer to that of the human race ; of which, namely, some individuals of a similar kind have only male organs, and the same males sprinkle their seed on the female eggs of others. Very many cold ones sprinkle their seed upon the eggs after they are poured out of the body of the mother. Warm animals inject their semen into the uterus of the female. But now, if eggs are generated within the body of the female, they are brought forth covered with shells or membranes ; but if the female has a live foetus in its uterus, it is born quite free of any involucrum : but the difference between these oviparous and viviparous animals is but small ; so that in the same class, and the same genus, some animals lay eggs, others produce live foetuses ; and lastly, the same animal sometimes lays eggs, and sometimes brings forth live young.

From this review of animals it appears, that all animals are produced from others similar to themselves ; many from a part of it similar to the whole ; others from an egg of a peculiar structure ; but that all these do not stand in need of male semen. Lastly, the more moveable and lively animals only, whose bodies are of a more complicated structure, are endowed with a double system for generation ; and the difference of sexes seems to be added for the bond of social life, and for the safety of a less numerous progeny.

For the certain effusion of this male juice into the female organs, both sexes are inflamed with the most vehement desires ; the male indeed has the most lively ones, because the female is at all times ready to suffer the venereal congress ; and thence it behoves the male to be animated with a desire of venery, when he has plenty of good seed, and such as is of a prolific nature. Therefore this is the greatest cause of venereal desire in him ; but in females, of the brute kind especially, some

some kind of inflammation in the vagina, which excites an intolerable itching.

But nature has first added to the womb, both in women and in quadrupeds, a vagina or round membranous cavity, easily dilatable, which, as we have already seen, embraces and surrounds the projecting mouth of the uterus; from whence it descends obliquely forward under the bladder, and resting upon the rectum with which it adheres, and lastly opens under the urethra with an orifice a little contracted. This opening, in the foetus and in virgins, has a remarkable wrinkled valve, formed as a production of the skin and cuticle, under the denomination of *hymen*, which serves to exclude the air or water; not perhaps without some kind of moral use, seeing this membrane, as far as we know, is given to women alone. This membrane being insensibly worn away by copulation, its lacerated portions at last disappear. The caruncles, which are called *myrtiformes*, are partly the remains of the shattered hymen, and lastly the valves of the mucous lacunæ hardened into a kind of flesh.

At the entrance of the vagina are prefixed two cutaneous productions or appendages, called *nymphæ*, continued from the cutis of the clitoris, and from the glans itself of that part; and these, being full of cellular substance in their middle, are of a turgescent or distensible fabric, jagged and replenished with sebaceous glandules on each side, such as are also found in the folds of the prepuce belonging to the clitoris. Their use is principally to direct the urine, which flows betwixt them both from the urethra, that in its descent it may be turned off from clinging to the body, in which office the nymphæ are drawn together with a sort of erection. These membranous productions descend from the cutaneous arch surrounding the clitoris, which is a part extremely sensible, and wonderfully influenced by titillation; for which it is made up, like the penis, of two cavernous bodies, arising in like manner

ner from the same bones, and afterwards conjoining together in one body, but without including any urethra. It is furnished with blood-vessels, nerves, and levator muscles, and a ligament sent down from the synchondrosis of the os pubis, like those in men, like unto which the clitoris grows turgid and erect in the time of coition, but less in those who are very modest; but from friction, the clitoris always swells up and is erected.

The muscle, termed *ostii vaginalæ constrictor*, seems to compress the lateral venal plexuses of the vagina, whence it every way conduces to retard the return of the venal blood. The transverse muscle of the urethra, and the bundle from the sphincter inserted into it, have the same situation as in men.

When a woman is invited either by moral love, or a lustful desire of pleasure, and admits the embraces of the male, the penis, entering the vagina, rubs against its sides, until the male seed breaks out and is poured into the uterus. In like manner the attrition of the very sensible and tender parts, which lie within the vagina, excites a convulsive constriction, as we observed before of the male. By these means the return of the venous blood being suppressed, the clitoris grows turgid and erect, more especially in lustful women; the nymphæ swell on each side, as well as the venal plexus, which almost surrounds the whole vagina, so as to raise the pleasure to the highest pitch: in consequence of which there is expelled, by the muscular force of the constrictor, but not perpetually, nor in all women, a quantity of lubricating mucous liquor, of various kinds. The principal fountains of this are seated at the first beginning or opening of the urethra, where there are large mucous sinuses placed in the protuberant margin of this uriniferous canal. Moreover, there are two or three large mucous sinuses, which open themselves into the cavity of the vagina itself, at the sides of the urethra, in the bottom of the sinuses which are formed

by the membranous valves fulcated upward. Lastly, at the sides of the vagina, betwixt the bottoms of the nymphæ and the hymen, there is one opening, on each side, from a very long duct; which, descending towards the anus, receives its mucus from a number of very small follicles.

But the same action which, by increasing the pleasure to the highest degree, causes a greater conflux of blood to the whole genital system of the female, occasions a much more important alteration in the interior parts. For the hot male semen, penetrating the tender and sensible cavity of the uterus, which is itself now turgid with influent blood, does there excite, at the same time, a turgescence and distention of the lateral tubes, which are very full of vessels, creeping betwixt their two coats, and now stiff with the great quantity of blood they contain; and these tubes, thus copiously filled and florid with the red blood, become erect, and ascend, so as to apply the ruffle or fingered opening of the tube to the ovary. In the truth of all these particular changes, we are confirmed by dissections of gravid or pregnant women, under various circumstances; also from the comparative anatomy of brute animals, and from the appearances of the parts when diseased.

But, in a female of ripe years, the ovary is extremely turgid, with a lymphatic fluid, which will harden like the white of an egg, and with which little bladders are distended. In a prolific copulation, some one of the more ripe vesicles is burst, a cleft manifestly appears, and at length pours out a clot of blood. Within this vesicle, after copulation, a kind of flesh grows up, at first flocculent, then granulated, and like a conglomerate gland, consisting of many kernels joined together by a cellular substance; which flesh by degrees becoming larger and harder fills the whole cavity of the vesicle, and is hardened into the nature of a scirrhus, in which, for a long time, remains a cleft, or a vestige of one. This is the *corpus luteum*, and the

number of these, for the most part, corresponds with that of the foetuses ; and they are common to all warm quadrupeds, in which some late anatomists have found a sort of juice before copulation ; which, however, experience does not admit, seeing there is no corpus luteum at that age. Nor is the vesicle, which is the human ovum, contained in a body like a cup.

The extremity of the tube, therefore, surrounding and compressing the ovary in a prolific congress, is thought to press out and swallow a mature ovum, from a fissure in the outer membrane, from whence it is continued down, by the peristaltic motion of the tube, to the uterus itself ; which peristaltic motion begins from the first point of contact with the ovum, and urges the ovum downward successively to the opening into the fundus uteri, which is very manifest in brute animals. The truth of this appears from the constant observation of a scar or fissure in the ovary, which is produced there after conception ; from a foetus being certainly found in quadrupeds, both in the ovary of the female and in the tube ; from the analogy of birds, in which the descent of the ovum from the ovary is very manifest. Yet we must acknowledge, that a true ovum was never found in quadrupeds, unless after a long time. It is probable, that at the time of conception, the true ovum is almost fluid, very soft and pellucid, and cannot be distinguished from the mucus with which the tube is filled ; likewise, that it is very small, on account of the narrowness of the tube. The vesicle itself which was in the ovary remains in it fixed, and becomes the covering of the corpus luteum. But the accounts of ova said to have fallen from women during the first days are not certain, and are contradicted by the smallness of the foetus observed many days after conception ; by the shape in which it is first observed, which is always oblong, and in brutes even cylindrical ; and likewise by the smallness of the tube.

These things are performed, not without pleasure to the

the future mother, nor without a peculiar sort of sensation of the internal parts of the tube, threatening to induce a swoon. Neither is the place of conception in the uterus, to which certain experience shows that the male semen comes. For the power of the male semen fecundates the ovum in the ovaria themselves, as we see in the case of foetuses found in the ovaries and tubes; from the analogy of birds, in which by copulation one egg indeed falls into the uterus, but very many are fecundated at once in the ovaria. Nor is the small quantity of the male semen, or its sluggish nature, any objection to this, which by eminent anatomists has been thought to render it less fit for performing such a journey. For it is certain that the male semen fills the tubes themselves at the first impregnation, both in women and brute animals.

The uterus indeed, in animals certainly, and in women probably, is closed, lest the very small ovum, together with the hope of the new progeny, should perish. At that time the new mother suffers many disagreeable affections; which probably arise from the subputrid and subalkaline male semen resorbed into the blood. A nausea is occasioned by conception, almost in the same manner as by swallowing a bit of a rotten egg. Flesh is at this same time chiefly nauseated; a vomiting also occurs; some pustules break out, and the teeth ach. The most of these complaints we reckon to be owing to the swelling of the uterus, and the retention of the menses.

These changes, hitherto, which are proved at least by the testimony of our senses, may be either confirmed or corrected. Those which follow are more conjectural; and the more difficult on account of the paucity of experiments, and their disagreement with one another. And in the first place, it is a difficult question, From whence proceed the first stamina of the new animal? Whether are they from both parents, and mixed into one animal by a conjunction of seminal matter coming

coming from the whole body ; as indeed there is a resemblance of the foetus to both parents in animals, but especially in plants, as confirmed by very many experiments : the same thing also seems confirmed by the faults of parents being conveyed to their children. But no seed has ever certainly been observed in females ; and innumerable examples show, that the species of animals may be propagated without any mixture of seeds. Lastly, the resemblance of the young animal to its father seems only to show, that in the male seed there is some power, which alone can form the soft matter of the embryo in its least state ; just in the same manner as that power adds length to the pelvis in certain bodies, dilates the larynx, and causes the horns appear.

To the father some have attributed every thing ; chiefly since the seminal worms, now so well known, were first observed in the male seed by the help of the microscope, which are observed with truth to agree in figure with the first embryos of all animals. But in these animals there is a proportion wanting betwixt their number and that of the foetuses ; they are also not to be constantly observed through all the different tribes of animals ; they have too great a resemblance to those animalcules that are every where spontaneously produced in other juices, which yet are always tenacious of their own genus, and are never found to grow in the most dissimilar kinds of animals that have limbs.

Again, other anatomists, not less celebrated or less worthy of credit, have taught that the foetus existed in the mother and maternal ovary ; which the male semen excites into a more active life, and likewise forms it variously, so as to show it just brought into life, and make its presence manifest. That yolks are also manifestly found in the female ovaries, even although they have not been impregnated with any male semen. But a yolk is known to be an appendix to the intestine

of fowls ; and to have its arteries from the mesenteric artery, and the covering of the yolk to be continued with the nervous membrane of the intestine, which is continuous with the skin of the animal. That along with the yolk, therefore, the foetus seems to be present in the mother hen, of whom the yolk is a part, and which gives vessels to the yolk. Lastly, that the analogy of nature shows that many animals generate eggs without any connection with a male of the same species, but that a male animal never becomes prolific without a female. That the progressions are continued from a female quadruped to an oviparous animal, and from that to one which is not oviparous ; but that the new animal proceeds from a part of the old one. Certainly, therefore, the males must give some addition to that sex which produces the foetus from its own body ; which addition is necessary in some tribes of animals, but in others, even the most fruitful, may be wanted. And that it is not possible with any kind of truth to admit of any insertion, by which the open navel of the male animal, when conceived, should adhere to the vessels of the female. For this navel would be by far too small at the time when the yolk is of a considerable bigness ; neither could the very small umbilical arteries be applied to the very large yolk with any hope of a continuance of the circulation.

Thus much concerning the materials : but we are again at a loss concerning the formation, by what means the rude and shapeless mass of the first embryo is fashioned into the beautiful shape of the human body. We readily reject such causes as a fortuitous concourse of atoms, the blind attractions between the particles of the nutritious juices and the strength of ferments, unconscious of the reasons why they operate ; the soul is certainly an architect unequal to the task of producing such a beautiful fabric ; as for internal models, we shall refer them to those hypotheses which the desire

desire of explaining those things, of which we are unwillingly ignorant, has given rise to.

To Haller, indeed, experience seems to agree with those things which the mind foresees will follow from their own causes. Namely, that this most beautiful frame of animals is so various, and so exquisitely fitted for its proper and distinct functions of every kind, and the offices and manner of life for which the animal is designed; that it is calculated according to laws more perfect than any human geometry; that the ends have been foreseen in the eye, in the ear, and the hand; so that to these ends every thing is most evidently accommodated: it appears, therefore, certain, that no cause can be assigned for it below the infinite wisdom of the Creator himself. Again, the more frequently, or the more minutely, we observe the long series of increase through which the shapeless embryo is brought to the perfection necessary for animal life, so much the more certainly does it appear, that those things which are observed in the more perfect foetus have been present in the tender embryo, although the situation, figure, and composition seem at first to have been exceedingly different from what they show themselves to be at last; for an unweared and laborious patience has discovered the intermediate degrees by which the situation, figure, and symmetry, are insensibly reformed. Even the transparency of the primary foetus alone conceals many things which the colour added a little after does not generate, but renders conspicuous to the eye. And it sufficiently appears that those parts which eminent anatomists have supposed in aftertimes to be generated, and to be added to the primeval ones, have been all cotemporary with the primeval parts, only small, soft, and colourless.

It is highly probable, that for a long time the latent embryo neither increases nor is agitated, except by a very gentle motion of the humours, which we may suppose to librate from the heart into the neighbouring

arteries, and from these into the heart of the foetus, But we may also suppose, that the stimulus of the male semen excites the heart of the foetus to greater contractions, so that it insensibly evolves the complicated vessels of the rest of the body by the impulse of the humours, and propagates the vital motion through all the canals of the little body of the animal; that it is more quick in some parts, and more slow in others; and that from thence it happens that some parts of the body of the animal seem to be produced very early, and others to supervene afterwards; and lastly, that some do not show themselves until a long time after birth, as the vesicles of the ovaries, the vessels of the male testicles, the teeth, hairs of the beard, and horns of brute animals. In all animals, heat assists this evolution; in the more simple ones, whose vessels are few, and less complicated in their various origins, it is the sole instrument of bringing it to perfection.

Of the objections which are usually brought, some are not true; such as the supposition of an excrescence of a different structure from the rest of the body; others seem to belong to causes depending on some accident, such as most kinds of monsters; some to the increase of some particular parts, occasioned by the powers of the male seed; some to the cellular texture variously relaxed, as it seems to increase in the parts newly produced, or to be occasioned by indurated juices. Although it is not easy to explain every thing mechanically, yet we ought to remember, that if indeed the new animal is truly, and shown by experience to be, present in the egg, those difficulties which are moved cannot overturn such things as have been truly demonstrated, although perhaps some things may remain, to which, in so great an infancy of human knowledge, we cannot yet give a full answer.

When the human ovum is brought down into the uterus, we become more sensible of its change of shape after the interval of a few days. The ovum itself sends out

out every where soft branchy flocculi from the superficies of its membrane hitherto smooth, which adhere to and inoscultate with the exhaling and resorbing flocculi of the uterus. This adhesion happens every where in the uterus; but chiefly in that thick part which is interposed between the tubes, and is called the *fundus uteri*. Thus the thin serous humour of the uterus, proceeding from its arterial villi, is received into the slender venous vessels of the ovum, and nourishes it together with the foetus. But before this adhesion, it is either nourished by the matter it already contains, or else by such juices as it absorbs from the surrounding humours, if indeed there is any time when it does not adhere.

At this time, in the ovum, there is a great proportion of a limpid watery liquor, which, like the white of an egg, hardens by the heat of fire, or a mixture with alcohol; and now the foetus, for a long time invisible, as Haller has never observed it before the 17th day, makes its appearance at first a shapeless mass, consisting of mere mucus, and as yet seemingly of a cylindrical shape. When some distinction of parts is next to be seen, it has a very great head, a small slender body, no limbs, fixed by a very broad flat navel to the obtuse end of the ovum.

From henceforward the foetus continually increases as well as the ovum, but in an unequal proportion; for while the arterial serum is conveyed by more open passages into the smaller vessels of the ovum, the foetus itself grows the fastest; because now the greatest part of its nourishment seems to pass through the very large umbilical vein. At the same time the ovum itself also grows, but less in proportion; and the waters, which it includes, gradually diminish from their first proportion, in respect of the bulk of the foetus. The fleecy productions of the vessels from the ovum are gradually spread over with a continued membrane, and only those which sprout out from the obtuse end of the ovum

take root, or increase so as to form a round circumscribed placenta or cake.

Such is the appearance of the ovum, as we have here described it, commonly in the second month; from which time it changes only by increasing in bulk. That part of the ovum next the fundus uteri is commonly uppermost, making about a third of its whole surface, in form of a flat round dish or plate; succulent, fibrous, full of protuberances, but throughout perfectly vascular; changing into other tubercles of the same kind, for the most part accurately, and often inseparably, connected with the uppermost part of the uterus, remarkable for its large vessels, of a thin cellular texture, collecting the vessels every where, but chiefly in the circumference of the greatest circle, as well the exhaling arteries answering to such as come from the uterus into the veins of the placenta, as the arteries of the placenta opening into the large veins of the uterus. There, in the common surface of the uterus and placenta, a communication is made, by which the uterus sends to the foetus, first that white serous liquor not unlike milk, and lastly, as it seems, red blood itself. This communication of the humours seems to be demonstrated by the suppression of the menses in women with child, whose blood must be turned into another channel; from the loss of blood which follows from a separation of the placenta in a miscarriage; and from the blood of the foetus being exhausted from an hemorrhagy in the mother; from hemorrhagies that ensue from the navel-string, so as to kill the mother when the placenta has been left adhering to the uterus; and, lastly, from the passage of water, quicksilver, tallow, or wax, injected from the uterine arteries of the mother into the vessels of the placenta, as is confirmed by the most faithful observations. But that it is blood which is sent into the foetus, is evinced by the magnitude of the sinuses of the uterus and placenta; the diameter of the serpentine arteries of the uterus; the hemorrhagy

morrhagy that follows, even when the placenta is very slight hurt ; but especially by the motion of the blood, which, in a foetus destitute of a heart, could only be given to the humours of the foetus by the blood of the mother.

Though it is probable the child is nourished in the way above mentioned, yet, as it is not fully proved, and as many physiologists take up the opposite side of the question, it may not be improper to repeat what Wrisberg has said on the subject.

" The manner in which the foetus is nourished after conception, labours under a like difficulty with the origin of conception itself. Of the two most noted conjectures which usually explain the communication of the uterus with the placenta, resorption, or the immediate anastomosis of the blood-vessels, the last has always had the most partisans. I am sorry that various arguments, sufficiently weighty, prevent me from so easily embracing the same side ; which arguments my celebrated pupils, Balthaser and Moeller, have already mentioned, and which shall now be partly delivered by myself. They may be conveniently divided into two classes ; the first contains the doubts of anastomosis ; the last, the arguments tending to prove it. In the first class it is denied,

" 1. Because the young of birds, removed at a great distance from their mother, so that they cannot get any blood from her, prepare true blood from their own nourishment, the yolk and white.

" 2. Anastomosis between vessels of so great magnitude and importance, the abstraction of which so large a hemorrhagy frequently follows, ought not to be formed and supported by vessels so very small and imperceptible to the naked eye, but by larger ones ; the number of which, however, in the natural abstraction of the secundines, we find neither in the uterus nor placenta to be great.

" 3. As often as I have taken the egg from the uter-

rus of animals which have died at different periods of pregnancy, I always found in the uterus a liquor resembling milk, rarely blood.

" 4. By the most successful injections, made with all due care, once into the uterus of a pregnant woman who died in the seventh month of gestation of a wound, several times into the wombs of mares, cows, goats, rabbits, dogs, and cats, &c. preparations of which I possess, I never could convey the smallest quantity of the most subtle liquor into the uterus from the vessels of the cord, nor from the vessels of the uterus into the placenta : the liquor entered only the cellular texture of the fungous chorion, and filled it with irregular particles.

" 5. I have sometimes filled the recent secundines of women, and several brutes, that have come away spontaneously immediately after birth ; but I never saw the mercury rushing forward, as we should have observed in the rupture of anastomosing vessels, which nevertheless penetrates the most subtle vessels.

" 6. I have met with a few dogs just before birth killed by cutting through the carotids ; which being almost half alive, I have filled through the uterine vessels with a very subtle liquor. The preparations which I possess are proofs of the most happy and successful injection. However, I have done nothing more in these than to push the fluid and coloured matter into the cells of the fungous chorion ; but there are not the smallest traces of its entering the vessels of the placenta. As to the other side of the question, the arguments there are not of less weight : for,

" 1. The suppression of the menses in pregnancy cannot so much prove it, since (a) several animals have no menses ; (b) they are not suppressed in all women ; (c) the mass of menstrual blood suppressed after conception, amounting to twelve, sixteen, or even twenty ounces, can in no ways be expended upon the small mass

mass of embryo of the first or second month, which, together with the secundines, weighs scarce an ounce.

" 2. Those great and dangerous hemorrhages which happen after the abstraction of the human placenta, excite no small suspicion of an immediate anastomosis. But (a) the flow of blood does not happen in all with the same force; but is sometimes several pounds, sometimes a few ounces and drachms: (b) and the same flux is the more gentle the more carefully the abstraction has been performed, and *vice versa*; and in very profuse fluxes the uterus is, for the most part, more or less injured. (c) I have seen abortions of two or three months attended with a very small profusion; and I now remember five in which scarce an ounce was lost. (d) In the birth of brutes, so large effusions never happen, or do not last so long.

" 3. It would truly be a weighty argument, which would easily determine me to embrace the doctrine of anastomosis, if I could reconcile it with my own observations, that the foetus is deprived of great part of its blood if the mother has died of an hemorrhagy. But I have seen (a) a human foetus whose mother had died in the seventh month of gestation of a very bloody wound, and had suffered a great effusion, which had lost no blood out of the heart nor larger vessels; nay, not even in the placenta itself did the state of the blood-vessels exhibit any mark of hemorrhagy. (b) Next, I have killed pregnant dogs and cats, just upon the time of birth, by cutting the carotids; I have examined the uterus of cows and mares, killed by means of a very large wound of the heart, without finding in any of them either the ova or foetus showing the least defect of blood.

" 4. That mothers may suffer fatal hemorrhages from cutting and not tying the cord, neither my own observations, nor those of Roederer, will allow; and no person at present directs midwives to begin the tying of the cord towards the placenta.

" 5. The

" 5. The venous sinuses, so called, in the uterus, except the cellular substance of the fungous chorion, seem to afford no proof. I have observed such sinuses, so called, in the uterus, if a very great part of the spongy chorion has cohered to the uterus. I have perceived them on the placenta, if it had adhered to it. The blood detained here does not absolutely demonstrate the continuation of vessels : it only shows, that a certain store is prepared, from which the absorbent vessels of the placenta may receive their nourishing matter, which contains a mixture of the blood itself transmitted through the increasing veins, whose residuum is reabsorbed by the veins of the uterus, and at length mixed with the blood. Does not the like happen in other spongy parts ?

" 6. As to examples of foetuses wanting the heart, whose circulation therefore should have depended upon the mother alone, although I am not so certain of the truth of them, I could oppose as many other observations of a similar monstrous mechanism in birds."

The remaining part of the ovum, and likewise the surface of the placenta, are covered by an external villous and fleecy membrane, full of pores and small vessels, of a reticular fabric, easily lacerable, so as to resemble a fine placenta, and is called the *spongy chorion* : (this is elegantly delineated by Dr Hunter). But even this is connected to the flocculent surface of the uterus, which is very like to itself, but softer, by vessels smaller than those of the placenta, but manifestly inosculated from the chorion into the vessels of the uterus.

Under the spongy chorion lies a continuous, white, opaque, and firm membrane, not vascular, which does not cover the part of the placenta turned towards the uterus, but is concave, and turned to the foetus. It coheres by a cellular texture both to the spongy chorion and amnios. The most simple name we can give it, is the *læve chorion*.

The innermost coat of the foetus, which is called *amnios*,

*amnios*, is a watery pellucid membrane, very rarely spread with any conspicuous vessels, extremely smooth, and in all parts alike ; also extended under the placenta with the former, the surface of which is every way in contact with the waters. If there are more foetuses than one, either in man or beast, each of them has their proper amnios.

The nourishment of the foetus, from the beginning to the end of the conception, is without doubt conveyed to it through the *umbilical vein*. This gathers its roots from the substance of the placenta, and it has manifest communications by some roots with the umbilical artery, from whence it in part rises, and, meeting together in a large trunk, is twisted in a circular manner through a number of folds to a sufficient length, that may allow of a free motion ; and in this course it is surrounded with a cellular substance full of mucus, distinguished by three partitions, and the membrane which is continued to the amnios, but known by the name of the *umbilical rope* ; and after forming some protuberances, it enters through the navel, in an arch made by a parting of the skin and abdominal muscles, and goes on through a proper sinus of the liver, into which the smaller portion of the blood that it conveys is poured through the slender *duclus venosus* into the *vena cava* seated in the posterior fossa of the liver : but the greater part of its blood goes thro' the large hepatic branches, which constantly arise from its *sulcus*, and remain even in the adult ; but it goes thence to the heart by the continuous branches of the *vena cava*. The sinus or left branch of the *vena portarum* itself is a part of the *umbilical vein*, and its branches bring the blood from the placenta to the *cava*, while the right branch alone carries the mesenteric and splenic blood through the liver.

But this is not all the use of the placenta ; for the foetus sends great part of its blood again into the substance thereof, by two large *umbilical arteries*, which are

are continued on in the direction of the aorta ; and after giving some slender twigs to the femorals, with still smaller arteries into the pelvis, they ascend reflected back with the bladder on each side of it, surrounded with the cellular plate of the peritonæum, with some fibres spreading to them from the bladder and urachus, in which manner they proceed on the outside of the peritonæum into the cord at the navel, in which passing alternately in a straight and contorted course, they form various twistings or windings, somewhat sharper than those of the vein which they play around ; in which manner they at last arrive at the placenta, whose substance is entirely made up of their branches, in conjunction with those of their corresponding veins, and a slippery cellular substance following both vessels ; so that the kernels themselves, that are conspicuous in the placenta, are convolutions of those vessels. By these branches the blood seems to pass out through the minute arteries of the placenta into the veins of the maternal uterus, that after undergoing the action of the lungs by the mother's respiration, it may return again in an improved state to the foetus : for what other reason can be assigned for such large arteries, which carry off above a third part of the blood of the foetus ?

But it will perhaps be demanded, Whether the foetus is not nourished by the mouth likewise ? Whether it does not drink of the lymphatic liquor contained in the cavity of the amnios, which is coagulable, unless putrefied, and in the middle of which the foetus swims, and whose origin is not sufficiently known ? Whether this opinion is not in some measure confirmed by the open mouth of the foetus, and the analogy of chickens, which are under a necessity of being nourished from the contents of the egg only ? to which add the absence of a navel-string in some foetuses ; the quantity of meconium filling the large, and part of the small, intestines ; the similitude of the liquor found in the cavity of the stomach to that which fills the amnios ;

the proportionable decrease of the liquor amnii, as the fœtus enlarges ; the glutinous threads which are found continued from the amnios, through the mouth and gula, into the stomach of the fœtus ; the true feces found in the stomach of the fœtus of quadrupeds ; the open mouth of the fœtus, which we have certainly observed ; the gaping of a chicken swimming in this liquor, and its attempts as it were to drink it up ? Again, what are the fountains or springs from whence this lymph of the amnios flows ? whether it transudes thro' the invisible vessels of the amnios, or through certain pores from the succulent chorion, which is itself supplied from the uterus ? It must be confessed, that these inquiries labour under obscurities on all sides ; notwithstanding which, says Haller, there seems more probability for them than otherwise, since the liquor is of a nutritious kind, at least in the first beginnings of the fœtus, and derived from the uterus.

All the excremental feces, which are collected in the fœtus during the whole time of its residence in the womb, amount to no great quantity, as they are the remains of such thin nutritious juices, percolated thro' the smallest vessels of the uterus. Haller frequently observed, that the bladder was almost empty in the fœtus. However, there is generally some quantity of urine, collected in a very long conical bladder. But in the cavity of the intestines, there is collected together a large quantity of a dark green pulp, which appears to be a mixture of the bile and the remains of the exhaling juices.

It may then be demanded, Whether there is any allantois ? since it is certain that there passes out from the top of the bladder a duct called the *urachus*, which is a tender canal, first broad, covered by the longitudinal fibres of the bladder as with a capsule ; and afterwards, when those fibres have departed from each other, it is continued thin, but hollow, for a considerable way over the umbilical cord, yet so that it vanishes in

in the cord itself. Whether this, although it be not yet evident in the human species, is not confirmed by the analogy of brute animals, which have both an urachus and an allantois? But as for any proper receptacle continuous with the hollow urachus, it either has not yet been observed with sufficient certainty, or else the experiment has not been often enough repeated, to render the opinion general in the human species; and those eminent anatomists who have observed a fourth kind of vessel to be continued along the umbilical rope into its proper vesicle, will not allow that vessel to be called the urachus, and very lately have referred it to the omphalo-mesenteric genus. Wrisberg has seen two foetuses with a similar filament. He injected a third one with wax, and that filament which might impose upon us for the urachus was likewise filled. The artery ran from the vessels of the omentum to the cord, and was distributed in very small branches through the cellular texture of the cord, and upon the bladder; and in the human foetus, the urine is separated in a very small quantity: but it perhaps may be no improbable conjecture, that some portion of the urine is conveyed to a certain extent into the funiculus umbilicalis, and there is transfused into the spongy cellular fabric that surrounds it; and therefore, that, of all animals, man has the longest umbilical cord, because he alone has no allantois. But then this can take up but a small space, terminating in the funis, and hardly ever seems to reach as far as the placenta. Sometimes, even in an adult person, this open duct has brought the urine to the navel.

In the mean time, the foetus continues to advance in growth; the limbs by degrees sprout from the trunk, under the form of tubercles; and the other outworks of the human fabric are by degrees beautifully finished, and added to the rest, in the following manner:

The embryo which we first observed in the uterus of the mother was a gelatinous matter, having scarce any

proper shape, and of which one part could not be distinguished from another. There was, however, in that gluten a heart, which was the cause of life and motion; there were vessels which generated the humour of the amnios; there were therefore vessels of the umbilicus and yolk, the little trunks of which, being received from the foetus, are at that time very large, seeing they have lately begun to be observed. There was both a head and spinal column, both parts very large, and larger in proportion to the rest than ever. There were likewise, without doubt, all the rest of the viscera, but pellucid and of a mucous nature; for which reason, they may be observed some days sooner than can be hoped for from nature alone, if you render them opaque.

But in the whole foetus, an immense quantity of water is mixed together with a very little earth, as the very cellular texture surrounds it in a state between fluid and solid; seeing large drops of water are interposed betwixt the remote elements of the solid parts.

In birds there is added to this the vivifying gluten or white of the egg, which is of the nature of lymph; and the yolk, which is of an oily nature: in man, something of a milky nature, not altogether unlike the yolk of an egg, and the coagulable lymph. That the blood is perfected from the fat by the proper powers of the foetus, we are persuaded from the example of birds. From it are insensibly prepared all the other humours; but all of them at first mild, void of taste, colour and smell, and of a glutinous nature. The proper nature of every one of them approaches to that of serum; but some of them are not produced till many years after birth, for instance the semen.

The firm parts, even in a grown person, make much the smallest portion even of the harder parts of the human body; in the foetus they differ from the fluids, by a somewhat greater degree of cohesion; as yet, however, they are like a gluten, at first fluid, and afterwards

terwards more consistent. In these the fibres which we could not distinguish in the primeval embryo are by degrees produced ; the gluten, as it would seem, being shaken between the neighbouring vessels, part of the water expressed, and the terrestrial parts attracting one another. These fibres variously comprehend one another, and form a cellular texture, even in diseases, and intercept little spaces, in which there is a kind of humour. From this cellular substance are formed the membranes and vessels, and almost the whole body.

The vessels are the oldest parts of the body, and are prepared in the first delineation of the embryo. What first appears in an egg during the time of incubation, having any distinct form, are venous circles : but these veins fabricate the arteries, by which they both receive their juice, and the motion of that juice. They are not generated mechanically from an obstacle, as the arterial blood is found at that time. At first the trunks of the veins are conspicuous, afterwards the branches which convey the humours to the trunks. If they were produced from the arteries reflected, the branches would first be seen, and the trunks formed in the last place. Neither could the arterial blood, driven back by an obstacle, form those most beautiful circles, and bring back the vessels into the heart. It would rather flow irregularly through the cellular texture. And the primeval heart would soon lose its life, unless as much of the humours returned to the heart as was sufficient to keep up its pulsations.

There are, therefore, in the primeval foetus, such as we first observe it, some things more perfect and conspicuous ; others involved, invisible, and very small. The heart is the most perfect ; it is the only moveable and irritable part ; although it is in many respects different from what it is in an adult person. The brain is large and fluid ; the vessels formed which appear in the back next to the heart. The viscera, muscles, nerves, and limbs, are not yet to be seen ; the bones them.

themselves are present, of which the first appearance is a mucus, as are the vessels of the rest of the body. The other portion is that of the abdomen, the umbilical capsule of which is an immense hernia.

To this embryo is superadded motion, in man almost of the heart alone; as also in birds, whose formation does not take place without heat rather greater than that of the human body: yet, without the heart, heat destroys, instead of forming the foetus. It is the largest in proportion to the rest in these beginnings; afterwards its proportion to the other parts of the body grows gradually less and less. Its pulsations are also at this time the most frequent; and in the softest foetus the most powerful for impelling the humours, and distending and producing the vessels.

To the force of the heart is opposed what is of service however in forming the foetus, namely, the viscosity of the vital humours which collect the earthy elements. There is therefore in the embryo both an impelling force, which increases the parts longitudinally; and a resisting force, which moderates the increase, and increases the lateral pressure, and thus the distension. By the force of the heart all the arteries, but for easiness of expression we shall say only one artery, which represents all the rest, with all its surrounding cellular texture, is lengthened out; its folds are stretched out, and the same artery is dilated. And the blood by its lateral pressure makes an effort against the almost blind branches of the arteries, fills and evolves them, and sets them off at more obtuse angles: thus are produced spaces which make very little resistance, in which the glutten is deposited. In the very substance of the artery itself, while it is every where dilated, between its imaginable solid threads are prepared little reticulated spaces like a stretched-out net, which are equally fit for receiving humours. The largest of these are farmed round the heart and in the head, whither the impulse of the heart drives the humours in a straight direction, and in

the placenta : the lesser ones are in the inferior part of the body, from which the umbilical arteries subtract the greatest part of the blood.

The foetus increases very quickly, as is most evident in the example of a chicken, whose length the twenty-second day is to its length the first day at least as 1,000,000 to 1 ; and the whole increase of bulk in the bird during the remainder of its life does not exceed the fifth part of the increase of the egg the first day. For the foetus has a larger and more irritable heart, vessels larger in proportion, and likewise more numerous and relaxed, and the solid parts are mucous and distensible. The breast is later of coming to perfection, surrounded with membranes so soft, that they cannot be seen.

The embryo does not only increase in bulk, but is so remarkably altered in shape, that it comes forth into the light totally dissimilar from any thing that could be observed in it at its first formation. And first it is probable, that the articulations of the limbs are produced from the elongated arteries, that they are laterally knit together by a certain gluten, separately evolved, and at first that they sprout out very short, but afterwards increase by insensible degrees, and appear divided into distinct articulations, as the wings of a bat are formed from an open vascular net-work. Thus likewise the right ventricle of the heart is expanded by the blood coming to it in greater quantity ; and, being increased by degrees, equals the left.

On the other hand, the cellular texture, from its glutinous aqueous nature, by which earthy particles are continually brought to it, becomes insensibly harder ; by a gentle attraction contracts its parts, which were before straight, into various flexures ; and ties the auricles to the heart, from which they were as yet at a distance. So the muscles draw out processes from the bones by their continual pulling, and open small cavities

ties into large cells : the same likewise incurvate the bones, and variously figure them.

Pressure can do a great deal : to it we must attribute the descent of the testicles into the scrotum, after the irritable force of the abdominal muscles has taken place : to this also we must ascribe the repulsion of the heart into the breast, when the integuments of the breast are larger : to it we are to ascribe the length of the breast and the shortness of the abdomen, and the smaller size of the viscera of the latter ; because the air received into the lungs dilates the cavity of the thorax. But even the bones are variously hollowed out by the pressure of the muscles, blood-vessels, and even of the very soft brain itself ; and by the same means flesh is changed into a tendinous substance.

The power of derivation brings the blood into the pelvis and lower extremities from the closed umbilical arteries : the same, when the foramen ovale is contracted by the auricles drawn towards the heart, evolves the right ventricle of the heart : when the vessels of the yolk have taken up the whole length of the egg, and can receive no farther elongation, it dilates the umbilical arteries of the chick, and produces a new membrane with incredible celerity. On the other hand, but by the same power, after the blood has got an easy passage through some vessels of any part, the other parts which do not afford a like easy passage increase the less. The head grows less after the lower limbs have begun to increase in bulk.

A membrane may be formed from a humour of which the thinnest part is exhaled, as we have an example in the epidermis : from the same may be formed a cartilage as happens in the bones, or even a bone itself, or something of a stony nature, which is very frequent in the testicles of aquatic animals. The bones at first are soft, and of a mucous nature ; then they become of the consistence of jelly ; this afterwards be-

comes a cartilage; without any change made on the parts, as far as can be observed.

A cartilage, however, is not afterwards secretly changed into a bone. That never happens, unless lines and furrows have at first run along the cartilage: nay, the red blood has made a passage to itself through the vessels of the bones; but these vessels manifestly come from the nutritious trunks in the interior parts of the bone, and strike as it were in right lines on the cartilaginous extremity of the body of the bone, which they remove farther and farther from its middle. Round these vessels is formed a cellular texture and laminæ, which seem to press the vessels themselves towards the medullary tube. Lastly, in the epiphysis, which both remains much longer cartilaginous, and denies entrance to the blood, the red vessels penetrate through the crust which covers the extremity, as well as the others which come from the exterior vessels of the limbs. Thus also in the epiphysis is produced a red nucleus of a vascular texture, which, being gradually increased by vessels sent out from its surface, changes the rest of the cartilage into a bony nature.

In these long bones it seems evident, that the increase is owing to the arteries elongated by the force of the heart, and gradually extended to the extremities of the bones: but that the hardness is owing to gross particles at last deposited in the cartilage when its vessels admit the red blood. But even a bony callus never becomes sound till the newly formed red vessels have penetrated its substance.

The flat bones originate from something of a membranaceous nature. Over this the fibres spread themselves, at first in a loose net-work, but afterwards they become more dense, having the membrane for their basis; the pores and clefts between these fibres being gradually contracted and filled with a bony juice, at last perfect the nature of the bones.

That a heavy bony juice, consisting of grosser particles,

ticles, is deposited between the primeval fibres, is proved by the phenomena of the growing callus, which exudes in small drops, not from the periosteum, but from the inmost substance of the bone, and is hardened by degrees. But even a chymical analysis extracts that gluten from the bones ; and in an ankylosis it appears poured round the joint in a fluid, and manifestly fills up the chinks of the bones and intervals of the sutures. It contains gross earthy particles, which have been discovered by various experiments ; and the juice of madder which adheres to it, manifestly distinguishes it by its colour.

The periosteum covers the bones, as a membrane does any of the viscera ; and from its cellular productions follow the interior vessels of the bones : but, in the periosteum, there are neither straight fibres, nor an appearance of alveoli or laminæ, nor red vessels, while the bone grows hard in the egg ; nor does the periosteum at all adhere to the bone, except in the epiphysis, when it has assumed a bony nature in the middle ; and it is thinnest when the bone is in a cartilaginous state, but every where complete. In the flat bones it every where affords a basis for the bony fibres.

Therefore the head is large, every where membranaceous, in a few places cartilaginous on these first days of gestation, with a mouth deeply cut, and long jaws. In the foetus come to maturity, there are also rudiments of the teeth, which have a great deal of membrane as an appendage : the brain, at first fluid, and always soft, is itself very large, with large nerves : the eyes are big, and the pupil shut by a membrane : the breast is very short, but capable of extension, on account of a great quantity of cartilage : the abdomen is large, surrounded with membranes, with a very large liver : the bile is innocent and mucous : the intestines are at last irritable, and full of soft, green, excrement, when the foetus has now arrived at its state of maturity :

the kidneys are divided into lobes, are large, and have very big capsules : the pelvis is very small, so that the bladder, ovaries, and tubes, project from it : the genital system is dense, not yet evolved, nor preparing its juices : all the glands are large, particularly the conglobate ones, and full of a serous juice : the skin is at first pellucid, then gelatinous, and at last covered with a soft cuticle and sebaceous ointment : the fat is first gelatinous, and then grumous : the tendons soft, succulent, and not yet shining.

There is a great difference betwixt the circulation of the blood in the foetus and in the adult : that this may be understood, it is necessary to describe the organs by which it is performed. The first is the *thymus*, a soft loose gland, consisting of very many lobes, collected into two large upper horns, and two inferior shorter ones, which are however joined together by a great deal of long and lax cellular texture : this gland is large in the foetus, and occupies a great part of the breast : it is seated in the cavity of the mediastinum, and part of the neck ; and is wholly filled in its very inmost structure with a white serous liquor, which cannot be discovered without wounding it. This gland, in an adult, being continually lessened by the increase of the lungs, and by the aorta now become larger, gradually disappears. What is the use of this gland or its liquid, we are altogether ignorant ; but even all the other glands, especially the conglobate ones, are larger in the foetus than the adult, as we have just now observed.

The cavity of the breast is short in the foetus, and greatly depressed by the enormous bulk of the liver ; the lungs are small in proportion to the heart, and so solid as to sink in water, if they are every way excluded from taking the atmosphere into their spongy substance, in making the experiment. Since therefore the like quantity of blood which passes the lungs by respiration in adults, cannot be transmitted through the unactive

unactive lungs of the foetus, who has no respiration, there are other ways prepared in the foetus, by which the greater part of the blood can pass directly into the aorta, from the lower cava and umbilical vein, without entering the lungs. In the primeval foetus there is no right ventricle of the heart ; and therefore there is such a large opening of the right auricle into the left, that all the blood which comes by the vena cava immediately passes into the aorta, a very small quantity excepted, which goes to the inconsiderable and inconspicuous lungs. Afterwards in the foetus, now grown bigger, the lungs are indeed larger, and the passage from the right part of the auricle into the left is narrower, seeing the auricular canal is now taken into the heart, and the auricles themselves are become much shorter. But yet the septum betwixt the right and left auricle, conjoining them together, is perforated with a broad oval foramen ; through which the blood coming from the abdomen, and a little directed or repelled by the valvular sides of the right auricle, flows in a full stream into the cavity of the left auricle. But it is by degrees that the membranes of each sinus depart from each other, upward and backward, above the oval foramen into the pulmonary sinus, where they are connected on each side above, by several orders of fibres, which below are palmated or like fingers, so as to close up at first a small part, and afterwards a greater part, of this foramen, so as to leave only a small oval portion of it at liberty ; which lies free betwixt the round margin of the said oval foramen and the increasing valve, making in the mature foetus about a fifteenth part of the area or capacity of the mouth of the vena cava.

That the blood takes this course in the foetus, and that it does not on the contrary flow from the sinus of the left to that of the right auricle, is evident, from all manner of experiments and observation. For, first, the column of blood in the right sinus, is of all the largest ; and, as it is the returning one from the whole

body, cannot be exceeded by any other : but the left auricle has so much less blood in proportion than that of the right, insomuch as part of it flows through the duct or canalis arteriosus into the aorta, whence its contents will be much less than that of the right auricle : moreover the valve of the oval foramen, in a mature foetus, is so large, and placed so much to the left of the muscular arch or istmus, that when it is impelled by the blood from the left side, the valve, like a palate or shutter, closes up the foramen ; but being impelled from the right side, it readily gives way so as easily to transmit either blood or flatus, but it will retain even flatus itself when injected from the right, nor will it suffer it to pass back again to the right side.

Moreover, there is but a small portion of the same blood, which first entered the right auricle and ventricle of the heart, that takes its course through the lungs : for the pulmonary artery, being in the foetus much larger than the aorta, is directly continued into the ductus arteriosus ; which is larger than the light of both the pulmonary branches together, and greatly larger than the opening of the foramen ovale, and enters that part of the aorta which comes first in contact with the spine, under its left subclavian branch : by which means it transfers more than half the blood to the descending aorta, which must otherwise have passed through the left auricle and ventricle into the ascending branches of the aorta ; and this is the reason why the aorta in the foetus is so small at its coming out from the heart. By this mechanism an overcharge of blood is turned off from the lungs, by directing a great part of that fluid in a straight course to the umbilical arteries, and the powers of both sides of the heart are united in propelling the blood.

Those who have asserted that the foetus respires in the uterus, having made very few experiments, have neglected that most easy one which is made by water, in which the foetus will swim ; and likewise by the lungs,

lungs, which in a foetus are constantly heavy, and sink in water: lastly, they do not attend to the evident shortness of the breast, and smallness of the lungs. Whether or not it can take in air through the vagina of the mother, is very difficult to be determined: and we suspect it to be possible in a certain situation, that a well grown foetus, which is not too much compressed, may sometimes draw in air, while it sticks by a part of its body, between the parts of its mother.

As the foetus grows larger, so the uterus increases proportionably; the serpentine arteries of which it is composed being extended by the impelled blood, and stretched into a more direct course; while the veins having their trunks compressed by the great bulk of the uterus, and being unable to return the blood, swell out into immense sinuses; and lastly, from the menstrual blood retained in the uterus, and not yet quite spent on the foetus. Thus its thickness continues the same, because the greater quantity of blood and dilatation of the arteries and veins make up for the extenuation of its solid parts. But more especially the fundus, or upper part of the womb, increases beyond the rest; so that, by dilating the above tubes, these last seem thus to descend from the middle of the uterus, which now by degrees goes out of the pelvis, even as high as the colon and stomach itself, so as to compass all the abdominal viscera, more especially the bladder and rectum. The os uteri in the first months of gestation is drawn upwards with the uterus itself, and recedes from the entrance of the vagina: after the third month, according to Haller, but not till the beginning of the sixth month, according to Wrisberg, it again descends, and stretches into the vagina. The same becoming perpetually shorter, projects upon the close extremity of the vagina: it is, however, constantly tender; and, from that cartilaginous hardness which is observed in the virgin womb, is relaxed into a mucous softness. It is never perfectly closed or shut together,

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but only stopped up and defended from the air by thick mucus from the sinuses, and perhaps from the vesicles which are seated in the cervix uteri. Moreover, the cervix or neck of the womb itself, which has long remained unchanged during the last months of gestation, becomes likewise short, and forms a broad flat opening, of no length; which towards the time of delivery, is always more or less relaxed and gaping. As these matters advance, the foetus, which in the first months had no certain situation, being now grown to a considerable bulk, is, about the middle of the time of gestation, folded together into a globe, in such a manner that the head lies betwixt the knees; and being the heavier part, it subsides by degrees more and more into the pelvis towards the cervix uteri.

The various complaints in the uterus are now increased to the highest degree, being distended by the great quantity of blood retained in it; for nothing is more disagreeable to a human creature than a violent tension, unless it is done very gradually. From the head of the foetus sinking down into the pelvis, the rectum, bladder, and that part of the uterus next the neck, and which is the most sensible, are pressed, and become painful: the foetus, having received its full increase of bulk, distends the uterus every way; and that with the greater uneasiness, because, the waters being now taken away, the limbs which are fully formed, and the head, press much more vehemently on the uterus. It is thought also that the placenta itself, now very large, distracts the internal and naked surface of the uterus. From these causes arise at first slight endeavours of the uterus to free itself; and at last, when these causes are now got to their utmost height, such an uneasy sensation is occasioned by the impacted head of the foetus as arises from a collection of feces in the rectum; by which pain, therefore, the mother is constrained to attempt the birth of the child. The time of delivery comes on after the expiration of nine solar months,

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and is kept pretty exactly in every species of animals, although by some causes it may be accelerated or retarded for some weeks, according to the nature of these causes; whose power, however, we must not extend too far.

The tenesmus thus increasing till it is no longer tolerable, the mother uses all her efforts by very deep inspirations, which press downwards the uterus and viscera of the abdomen; and at the same time the womb itself, by its contractile vital force, constringes itself so powerfully about the foetus, as sometimes to exclude it, without further efforts from the mother. The difficulties of the birth, however, are evidently overcome principally by the efforts of the mother, while the mouth of the uterus, now very soft, suffers itself to be distended by the head of the foetus. Now the amnios, filled with the water, is first protruded vertically, before the head of the foetus, so as to dilate the os internum uteri: in which, the membranes being by degrees extenuated and dilated, easily break, and pour out their waters, which lubricate the passages, and relax all the parts of the vagina. The naked head of the foetus now presents naturally with the face to the os sacrum; directed that way by its weight: and being urged forward, like a wedge or cone, it further dilates the os uteri; till at length, by the more powerful efforts of the mother, which often loosen the bones of the pubes in young women, the head is thrust out through the dilatable vagina, with intolerable pain to the mother, and an universal tremor of body; and if none of the bones of the pelvis happen to press unequally, the infant easily advances, and is delivered into the world. This happens difficultly even in quadrupeds; but most of all in the human race, whose foetus has the largest head in proportion to its body.

It is natural for women to have but one child at a birth; which law they have in common with all the larger

larger animals, unless they are of the carnivorous kind. Frequently, however, they have two, more rarely three, and scarce ever five. It is not to be doubted, however, that a second foetus may be conceived while the first remains in the uterus; seeing women have frequently born children, when a hard and ossified foetus had been for a long time retained in their uterus.

The placenta of the foetus, connected with the fundus uteri, is, in the next place, separated from the womb without much difficulty in a mature birth, partly by the weaker throes of the mother, and partly by the extracting force of the deliverer; by which the fleecy or villous surface of the placenta being withdrawn from that of the womb, is immediately followed with a considerable flow of blood; and thus is the mother delivered from the secundines or after-birth. The umbilical cord of the foetus is next tied, before it is cut off; for it cannot be left open, without danger of a fatal hemorrhagy. Thus the umbilical vein is deprived of all the supplies of blood which it used to receive, and at the same time an insuperable obstacle is opposed to the blood, conveyed by the arteries of the same name.

The uterus, which hitherto had been distended beyond imagination, now contracts itself by the elastic power of its fibres, so suddenly and powerfully, as often to catch and embarrass the hand of the deliverer, and frequently retain the placenta, if it be not soon loosened and withdrawn. By this contraction of the womb, the bleeding vessels are compressed, no less than by the contraction of their own coats; whence the large quantity of blood that was collected in the uterine substance abundantly flows out, under the denomination of the *lochia*; at first a mere gore, but afterwards, as the openings of the vessels more contract themselves, they first become yellow, at length become of a whitish or wheyish complexion; and then the ample wound of the

the uterus is soon healed, and shrinks up to a bulk not much exceeding that of the virgin uterus.

But after two or three days are elapsed from the birth, when the lochial discharge has almost spent itself, the *breasts* begin to swell considerably ; and their ducts, which in the time of gestation often distil a little thin serum from the nipple, become now very turgid with a liquor, which is at first thin or like whey, but is soon after followed by the thicker chyle itself. For *milk* very much resembles chyle, but human milk less than that of other animals. It is white, thickish, sweet, and replete with a very sweet essential salt, which grows sour spontaneously, but is tempered by the oil and lymph added to it. It has also a volatile and somewhat odorous vapour, a good deal of fat or oily parts, a larger portion of a white crassamentum or cheezy curd, and still more of a diluting water ; and again, in the crassamentum, are contained parts of a more earthy, alkalescent, or animal nature. But when the chyle is once changed into serum, by fasting a considerable time, the milk becomes brackish, alkalescent, and displeasing to the infant. As the chyle, so the milk frequently retains the nature of the aliments and medicines taken into the stomach. The cause of this increased secretion in the breasts, seems owing to the revulsion, in consequence of the plentiful uterine secretion being suppressed, by which the foetus was nourished ; in the same manner as a diarrhoea is suppressed by increasing the perspiration. For it has been observed, that true milk will sometimes make its way through other parts besides the breasts, and even escape through wounds. And there is otherwise between the uterus and breasts some kind of nervous sympathy, and a similar fitness for generating a white liquor. For the uterus in infancy, and during the time of pregnancy, manifestly generates it. But the osculations betwixt the mammary and epigastric arteries, though true, are so small, that they can have but a very little share in this account.

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The *breasts* are made up with a very large quantity of soft surrounding cellular fat, of a white colour; and conglomerate glandules, of a convex figure, assembled into bunches somewhat round and hard, of a reddish blue colour, outwardly surrounded and connected by a firm web of the cellular substance, separating off into lesser kernels, which are common both to men and women. To these glandules a great number of blood-vessels are distributed from the internal mammaries, from the external vessels of the thorax, and sometimes from those of the shoulders, all which inosculate together around the nipple. The trunks of the mammary arteries, but not the *mammæ*, inosculate with the epigastric vessels, but the veins more evidently. The nerves are both large and numerous, like those of the more sensible cutaneous parts, being derived from the superior intercostals.

From the middle of this gland of the breast, and likewise from the surrounding fat, an infinite number of small ducts or roots arise, very slender, soft, white, and dilatable, which come from all sides to the middle of the nipple, and likewise into the circle which subtends its basis, and then run together on the area of that circle, and emerge at the root of the nipple, which they perforate round its margin, in a circular figure, after emerging through the root of the said *papilla* or nipple; for by this denomination we call a cavernous or spongy cellular body, into which the blood may pass out from its vessels, so as to cause a kind of erection, as in the penis. Through this papilla open about twenty or more of the excretory ducts from the breast, called *lactiferous*; none of which inosculate or join with the others, but are greatly contracted at their opening in the nipple to what they were in the breast: and these, in a loose or flaccid state of the nipple, are compressed, wrinkled, and collapsed together; but when the nipple is erected by any kind of titillation, they become straight and open, with patent mouths, lurking betwixt

betwixt the cutaneous wrinkles. This papilla or nipple is surrounded by a circle, planted with sebaceous small glandules, which defend the tender skin against the repeated attrition and perpetual moisture.

Thus the infant is naturally provided with its first food, which is otherwise exceedingly salutary to man. This the infant by instinct knows how to receive, although it is as yet a stranger to all the other offices of human life. Taking the nipple in its mouth, it causes it to swell by gentle vellications; the lips are pressed close to the breast, that no air may enter betwixt; at the same time the inspiration is deep, and a space formed in the back part of the mouth, in which the air is more dilated or rarefied; and thus, by the pressure of the external air, joined with that from the lips of the infant, the milk is urged from the breast through the nipple, in which it would otherwise be collected in so great a quantity, as sometimes to distil spontaneously and be very ready to flow out; and thus the infant sucks, and is nourished. The first milk, which is like whey, termed *colostra*, loosens the tender bowels of the infant, and purges out the meconium, to the great advantage of the infant. Yet it is also observable, the lactiferous ducts are so open, that when the nipples of the breast are distended by titillation, and a greater quantity of blood sent into the breasts, they have yielded milk, even from virgins, sometimes from old women, or even from men. Milk is only generated after puberty; before that time a serous humour flows from the breast; and for the most part it is generated only about the middle of pregnancy. After the menses have ceased, the breasts, as well as the uterus, become decayed, and cease to perform their office.

But great changes now happen to the little new-born infant; and the first is *respiration*, which it endeavours to exert, even before it is well set at liberty from the vagina of the mother; being probably excited, from the pain or anguish it feels, to those cries with which

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it salutes the light, and perhaps from the desire of food which it had hitherto taken in from the liquor of the amnios. At first, therefore, a portion of the air is admitted into the lungs, which are as yet small and full of moist vapours ; but being dilated from the air, change from a small dense body, sinking even in salt water, into a light spongy floating fabric, extended to a considerable bulk with air, and of a white colour. Now, therefore, the blood passes more easily into the enlarged and loose fabric of the lungs ; in consequence of which, a large portion of the blood that went before from the pulmonary artery, through the canalis arteriosus, into the aorta, goes now into and through the lungs themselves, by the other branches of the said pulmonary artery. And so much the more is the arterial duct or canal deserted, inasmuch as there is made a new obstacle to the descent of the blood into the abdomen ; for the umbilical arteries being now very straitly tied, the blood of the descending aorta cannot now find its way but by the same force with which it dilates all the arteries of the pelvis and lower extremities. Finally, as the lungs now receive more blood, so the aorta itself receives a greater quantity, and with greater force likewise from the heart ; whereupon the intermediate canal, betwixt the protuberant part of the aorta and pulmonary artery, closes up or shrinks to such a degree, that, in adults, it is not only an empty ligament, but likewise of very little length ; and otherwise it is singularly red in the inner part, soft, and very fit for concreting with the stagnating blood. This course of the blood, therefore, is soon abolished, commonly in about the compass of a year.

In the like manner also, the foramen ovale is, from the same causes, gradually closed up. For when the way is rendered more free and pervious into the lungs, it will likewise be more free into the right side of the heart ; whence the blood, both of the ascending and descending cava, will flow thither more plentifully, as

it is invited by the more lax pulmonary artery, into which it will rather move than through the passage through the septum of the sinuses. Again, the umbilical vein, being now almost destitute of any supply with blood from the ligature of the navel, less blood will from thence flow into the lower cava, and consequently the pressure against the oval mouth will be diminished; by which means the blood of the upper cava, being turned off by the isthmus, will be scarce able to penetrate the obliquity of the foramen ovale. Thence again, as more blood is derived through the lungs into the left sinus and auricle, its greater dilatation and extension will strain the little horns of the oval valve, so as to draw up and press the valve, together with the isthmus, whereby it is extended so far, as wholly to shut up the opening in the mature infant, while, at the same time, the blood, within the left sinus, props up the said valve, so as to sustain the impulse of the blood on the other side within the right sinus. Thus, by the accession of a little friction of the uppermost margin of the valve against the upper part of the isthmus, the foramen ovale closes up by degrees, and the upper margin of the valve forms a concretion to the posterior face of the isthmus. But this is performed very slowly; insomuch that frequently, in an advanced age, there will be some small aperture or tube still remaining; and where there is none of this tube, yet there are the remains of one, as a kind of sinus, hollow to the left side, that makes a tube opening upward to the right side, and blind or closed to the left, because the power of the blood in the right side is always greater than its resistance on the left, or certainly not less, even in the advance of life.

The *umbilical vein*, being deprived of blood, soon closes up. The blood of the *vena portarum*, having no opposition from that which formerly flowed through the umbilical vein, occupies the left sinus and curve of the umbilical fossa, and sends its blood through

those branches by which that of the umbilical vein before passed. Thence the *ductus venosus* being neglected, shrinks up and closes, by the new compression which the descending diaphragm makes upon the liver by inspiration; and by which the left lobe of the liver is pressed towards the lobule, and perhaps too from the obtuse angle which it makes with the left sinus of the vena portarum; for it is certainly first closed in that part which lies next the vena portarum.

The *umbilical arteries* are also closed up from the same causes, as other arteries usually are after a ligature, when some of the blood being at the same time compacted into a polypus, fills up the blind void part, while the other blood, flowing above, whose impulse was sustained by the resisting membranes, spreads itself through the adjacent less resisting branches, which are thereby rendered more open or diverging. Nor do we overlook the force of the abdominal muscles towards this effect, by which those arteries are compressed against the full abdomen in each respiration; and, again, the very acute angle in which the umbilicalis goes off from the iliac artery, now becomes a curve, by descending with the sides of the bladder, and is then directly extended into an acute fold, which the thighs make with the body of the foetus. Thus the capacity of these arteries is soon shut up, leaving only a small tube, that gives passage into two or three arteries of the bladder. The *urachus* being likewise a very thin tube, extended perpendicularly upward from the bladder, is therefore easily closed up; so that the contents of the bladder make no endeavours to pass that way, finding a ready outlet by the descending urethra.

From the like causes the bulk of the liver itself is lessened, and by degrees contracts itself within the capacity of the ribs; in the mean time the *intestina crassa*, from the slender condition in which they are observed in the foetus, dilate to a considerable diameter, and the stomach itself is gradually elongated; the large

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convexity of the cæcum forms itself by the force of the feces pressing perpendicularly downward to the right side of the vermicular appendix; and the lower limbs are likewise considerably enlarged by the return of the blood, sent back from the umbilical arteries now tied; and by degrees all the other changes are made, by which a foetus insensibly advances to the nature and perfection of an adult person.

#### § 9. Nutrition, Growth, Life, and Death.

AFTER birth the child continues to grow, but always more slowly the older it is. There are many concurring causes, why the growth is continually rendered less and less. Many vessels seem to be stopped up, both because they are compressed by the neighbouring torrent of blood flowing through the great arterious tube, and because the blood being now become more viscid runs into clots. But the harder kind of food that is now made use of, throws into the blood more terrestrial parts; which being carried through the whole body along with the nutritious parts, renders them all harder, as the bones, teeth, cartilages, tendons, ligaments, vessels, muscles, membranes, and cellular texture; so that an increase of hardness may be perceived in them, even by touching them with the finger. Wherefore, seeing the blood flows from the heart through fewer canals, and seeing all parts are grown harder, which should be lengthened or distended, it necessarily follows, that those which ought to increase in bulk, will yield less and less to the impulse of the heart.

But the heart likewise, which is the part that is first consolidated among all the soft ones, increases less than any other part of the whole body; and while the much more tender limbs and softer viscera are distended, the proportional bulk of the heart to the rest of the body grows continually less and less, till at last its propor-

tion to the body of the adult becomes eight times less than what it was in the new-born infant. At the same time, from that very density which it has so quickly acquired, it becomes less irritable, and is contracted less frequently within a given time. Thus, while the resisting forces are augmented, the distending ones are at the same time diminished.

There will therefore, sooner or later, be an end of the increase of bulk ; and that will happen so much the sooner as the heart has had the more frequent and vivid contractions : but this cessation of growth will take place when the cartilaginous crusts of all the bones are now become so thin, that they cannot yield to the increase of the bony part. In women, the menses seem to put a stop to the growth sooner than in men. In cartilaginous fishes, there is perpetual growth.

There is no state in which nature by a perennial progress induces a continual decrease from the first conception. It is said however to take place, when there is neither any increase of bulk, nor yet does any visible decrease take place.

For we are all perpetually consuming. Nor do we only lose the fluid parts of our bodies, but in short even those which are reckoned to be the most solid. For even the bones are changed ; and the teeth, which are harder than the bones, increase in bulk when the attrition of the opposite teeth has ceased to wear them away, and therefore their elements are changed : even the fibres of ivory in the elephant's teeth have quitted their places, and surrounded on each side in curve lines like a leaden shot : the bony juice likewise is changed ; seeing in some cases the bones grow soft, in others they swell out in bony tumors : even cicatrices themselves have a manifest growth, otherwise they would not be sufficient in an adult person to close up a wound which he had received when a boy ; and a great quantity of the earthy part of our bodies goes off by urine, as is proved by some diseases.

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The cause of the destruction of the solid parts lies in their perpetual extension and retraction, which happens at every pulse of the heart: this occurs an hundred thousand times every day; and by this motion even metals themselves are worn. Other causes are from the friction of the fluid against the solid parts; from the wearing away of all the membranes, which terminate with a moveable extremity, either on the surface or in the internal cavities of the body, the firmness of which only belongs to the rest of the canal; in the alternate swelling and decrease of the muscles; and in the attraction and pressure which at first form our fleshy parts. But all parts of our body are the sooner worn away, that they consist of a great deal of gluten combined with a small quantity of earth; and that gluten when it is extended, if the extension has been a little superior to the force of its cohesion, must of necessity fall away and be carried off from the earthy parts. Thus wrinkles or furrows are generated; such as are visible in the arteries of old men. The cellular texture, which otherwise would be dissolved into water or gelly, is worn away by the impetus of the blood pressing against the neighbouring blood-vessels and muscles, by friction, and by perpetual flexion and extension.

The decrease would be very quick, and indeed there would be no great distance between the end of our life and its beginning, unless these losses were repaired. The fluid parts are restored by the aliments, and that pretty quickly; as appears from the example of a chicken, in which blood is generated out of its aliment within two days. The fat, however, and red globules of blood, are formed out of the fat, as is shown elsewhere; the lymphatic juice from jelly; the mucus from mucus; and the rest of the humours from these and water. The solid parts are repaired almost by the same methods which we have described in the history of the foetus. A gelatinous juice is brought

from the aliments, through the arteries, to all parts of the body, and exudes into all parts of the cellular texture. The furrows, which we might imagine to be made in the inmost arterial membrane by the impetus of the blood, are filled up by a viscid matter brought into them by the lateral pressure; nor is it possible that these furrows can be overfilled, because every exuberant particle of nutritious juice must necessarily be carried off by the current of the blood. This will not be wanting while there is a sufficient quantity of aliment; while there is more rest, and less resistance, in the bottom of the furrow than elsewhere; which always must be the case, because the bottom is farther removed from the motion of the blood by the depth of its cavity. There seem to be certain powers in the air, by which the aliment is attached to the solid parts, although we are ignorant of the manner in which they act.

The decrease of the cellular texture arising from attraction or pressure, will be repaired by the viscid vapour exhaling from the artery, and pressed towards those places which stand in need of reparation by the force of the neighbouring arteries and compressing muscles, its aqueous part being pressed out and resorbed. The gluten repairs most of the organic parts, tendons, and membranes; being formed into a new cellular texture, as in the foetus.

The waste which takes place in moveable parts adhering by their other extremity to the rest of the body, can be repaired by protrusion alone, while the lymph fills up the intervals or hollows that are thus produced.

At that time when the growth of the body can proceed no farther, fatness is produced, which is a kind of imitation of real growth. This proceeds from the fat generated by the aliment; which by reason of the impetus of the blood being lessened, and its entering the smallest vessels with more difficulty, is carried to

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the sides of the vessels; enters the lateral ones and the inorganic pores of the arteries; exudes into the cellular texture; and there, the power of conquassation of the blood being now diminished, and likewise the absorption by the veins, the fat is consequently collected.

We feel the beginnings of decay even in youth itself. Even in that blooming season, the solid elements of the body are augmented, the chinks through which the humours flow are lessened, small vessels filled up, and the greater attraction of the cellular texture has added a density to the whole body. Throughout the whole body, that hardness occasioned by age is very conspicuous, in the bones now wholly brittle, in the skin, in the tendons, in the conglobate glands, in the arteries, and likewise in the weight of all the parts, and of the brain itself. But those parts grow stiff soonest which are most exercised by motion; as those in every mechanic, which he chiefly makes use of in his business.

Moreover, the arteries also continue to become more dense, more narrow, and even to be quite filled up, as well by the internal pressure of the blood flowing thro' the large arterial tube, as from the attraction of the cellular texture of which the greatest part of the artery is made up. An infinite number of parts of the cellular texture thereof cease to be nourished; to which the smallest arteries hitherto brought their nourishment, but now when stopped up can bring none. The extending force being removed, the cellular fleeces draw themselves together, contract the little spaces intercepted between them, degenerate into membranes, or substances of a hard texture, which intercept and as it were choak up other vessels. But the gelatinous vapour likewise concretes in the small hollows of the cellular texture, and unites into a hard solid with its sides. The muscles, having expelled the blood they

contained, and condensed their fibres, degenerate into hard dense tendons destitute of all irritable power.

At the same time the nerves become more and more callous to the impressions of the senses, and the muscles grow less sensible to the solicitations of the animal powers ; thus the contractile force of the heart, and the frequency of its pulsations, is diminished, and therefore the whole force which drives the blood into the smallest vessels.

The quantity of humours is diminished in a dense body, as is evident in the perspiration, semen, humours of the eye, and of the conglobate glands ; the vapour also which bedews the solid parts of the body every where decreases. For this reason nutrition now languishes, because there are more parts of the body which require nourishment, and less nutritious juice.

Nor is the quantity of humours only diminished ; they themselves are likewise corrupted. They were mild and viscid in children : but these same humours are now acrid, salt, fetid, with a great quantity of earth, in old men. This happens through the use of salt or putrid aliwents, the fault of which grows stronger by being collected through a great length of time ; also through the fault of a less perspirable skin, a constive belly on account of the diminished irritability, and thus the increased resorption of the putrid liquamen. Hence the fetor of the urine, of the breath, and the difficult healing of wounds.

But the greatest fault of the humours is, that they abound with earthy particles, as well those collected insensibly from the aliments after the secretions have become less free, as from those which are carried off from the solid parts and returned into the blood : of this consists the earth collected in some diseases, and which is of the nature of the gouty earth. By this quantity of earth, the portion of that element through the whole body is augmented, because the nutritious liquor brings too much of that along with it ; whence

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the brittleness of the bones, and the hardness of all the other parts, increases: the same is likewise every where deposited in the cellular texture, and produces crusts, which are first callous, then of a bony or stony nature, and that chiefly in the coats of the arteries.

The hardness or rigidity of the whole body, the decrease of the muscular powers, and the weakening of the senses, constitute *old age*; which happens to mankind sometimes sooner, and sometimes later: sooner if they have been subjected to violent labour, or given themselves up to pleasure, or lived upon unwholesome diet; but more slowly if they have followed a moderate way of life, and used temperance in their diet, or if they have removed from a cold to a warm country.

But when those causes continue to operate by rendering the matter of the body more dense, by diminishing its irritability, and augmenting the quantity of earth, it is not possible but decrepid old age must succeed. In it the senses are almost destroyed, the natural power of the muscles is exceedingly weak, the limbs lose their strength, the feet especially are not sufficient for supporting and directing the body. Thus the callous insensibility of the nerves cannot be incited to perform the office of generation: thus the very intestines becoming inactive, refuse to answer to the accustomed solicitations: thus also, by the induration of the cartilages interposed betwixt the vertebrae, the body bends forward; by the falling out of the teeth, the jaws now rendered shorter cannot support the lips as usual; and lastly, the heart loses one half of the frequency of its pulsation which it had in the infant state.

Thus at last natural death necessarily follows; but very many people are carried off before this time by diseases. Scarce one in a thousand exceeds the age of 90; but one or two perhaps may be found in a century that live to the age of 150. Man is long lived  
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when compared with other animals ; he is also more tender than any of them, has looser flesh, and less hard bones. Among the long-lived people, it is not easy to say what was the cause of that privilege. England seems to excel all other nations in the long-lived people ; and generally the temperate countries are remarkable in this respect. Among all the different professions, the commonalty has almost solely afforded these rare examples of longevity already mentioned ; although from the more numerous class, we might expect a greater number of examples. Some prerogatives of long life seem to be sobriety, at least a moderate and not very rich diet ; a mild behaviour ; a mind not endowed with very great vivacity, but cheerful, and little subject to care. Among animals, fowls are longer lived than many others, but fishes the most of all ; the latter have the smallest heart, and the slowest growth, and their bones are never hardened.

Death happens sometimes, but rarely, from mere old age. This we say happens when the powers are gradually lost, first of the muscles subject to the will, then of those that are subservient to the vital functions, and lastly of the heart itself ; so that old men cease to live through mere weakness, rather than through the oppression of any disease. We have often observed the same kind of death in brutes. The heart becomes unable to propel the blood to the extremities, the pulse and heat desert the feet and hands ; yet the blood continues to be sent forth from the heart into those arteries that are next to it, and to be carried back from thence : thus the flame of life is supported for a little while ; which we soon perceive to be extinguished, when now the heart itself being totally deprived of its powers, and not irritable by the blood to any effectual motion, cannot drive the blood through the lungs, that the aorta may receive its due quantity. Thus the utmost force of respiration is exerted in order to open a passage to the blood through the lungs, until even the powers

powers given by nature for performing the action of inspiration, become unequal to their task, and cease altogether. Thus the left side of the heart neither receives blood nor is irritated, and therefore remains at rest ; while yet for a little time the right ventricle, and lastly the auricle of the same side, receive the blood brought by the veins from the cold and contracted limbs, and by this means being irritated they continue to beat weakly. But lastly, when the rest of the body has become perfectly cold, and the fat itself congealed, even this motion ceases, and death becomes complete.

We would call that death, when the whole irritable nature has left the heart. For the mere resting of the heart is not without hope of a revival of motion : neither does the putrefaction of any part of the animal body demonstrate the death of the whole animal ; nor does its insensibility or coldness do so : but all these things when joined together, and perpetually increasing, with the stiffness which follows the coagulation of the fat by rest and cold, present the signs of death in any doubtful case.

The dead body now hastens to putrefaction. The fat, water, and gluten, in consequence of separation and dissolution, consume : the earth, deprived of its bonds of union, insensibly moulders away, and mixes itself with the dust : the spirit departs whither God hath destined it. By death it is indestructible ; which is manifest from the common and frequent observation of phthisical people, who, while their bodily powers are wasting by disease, evidently possess a most serene, lively, and joyful mind.

## C H A P. V.

*Of the ARTERIES in general.*

THE arteries are long extended cones, whose diameters decrease as they divide into more numerous branches: but where the arteries run for some length, without giving off large branches, their convergency, if any, is not very evident: at length they are cylindrical, or very imperceptibly diminished, when they are called capillaries, and wherever they admit only a single globule; the section being every where without exception circular in a distended artery. Where they send off large branches, the cavity is there suddenly diminished, insomuch that they might be taken for a chain of cylinders, of which every one is narrower than the preceding. If you reckon them cones, then the common basis of the cone in all arteries is either in the one or the other ventricle of the heart; and the apex of the cone terminates either in the beginning of the veins, or in the beginning of the cylindrical part of the artery, or in the exhaling vessel, unless it is cylindrical. In some places they seem to diverge or dilate; at least they become there of a large diameter, after they have been filled or distended with wax; which possibly may arise from some stoppage of the wax, by whose impulse that part of the length of the artery becomes more distended than the rest. Examples of this kind we have in the basilar artery, at the basis of the skull, in the splenetic artery, in the flexure of the carotid artery, according to Mr Cowper's injections; in the humeral artery near its division; and, lastly, unless these experiments deceive us, in the spermatic arteries in all places, likewise, where the ramifications between the diameter of the artery is a little increased.

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There is no external coat proper and perpetual to all the arteries; but the office of such a coat is supplied to some of them by one single external and incumbent integument, which in the thorax is the pleura, and in the abdomen the peritonæum. In the neck, arm, and thigh, a sort of thicker cellular substance surrounds the arteries. The membrane of the pericardium, which on all sides surrounds the aorta, returns back with the vessels to the heart. The dura mater imparts a capsule, that surrounds the carotid artery as it passes out through a hole in the skull. But the first true external membrane common to the arterial tube in all parts of the body, is the cellular substance, which in some parts (as in the thorax) we see replenished with fat.

This cellular coat is, in its external surface, of a more lax texture, painted with a great many small arteries and veins; and it has nerves running through its substance, which are none of the smallest. There is sometimes so much of this cellular substance about the artery, as might occasion one to think it hardly belonged to it as an external coat or lamella, but rather as some foreign net-work added to this vessel. Thus we find it in the arteries of the neck, groins, and subclavians; in the mesenteric, cæliac, and hepatic arteries; where it is chiefly interwoven with long fibres. And these are the *vaginæ* or capsules of the arteries, formerly observed by some eminent anatomists, and which, according to Wrisberg, are best seen in young animals, or in such as have laboured under a congestion or kind of suffocation.

As this cellular coat advances more inward, it becomes more dense, solid, and is tied more closely together by a kind of wool, and may be called the *proper coat* of the artery. That there is no tendinous coat of the arteries distinct from this last part of the cellular substance, is evident from maceration, whereby the inner stratum of this arterious tunic changes into

into a cellular fabric, which may be divided into several layers.

Within the former, there is a coat of muscular fibres, which are in general imperfect circles : that is to say, no fibre anywhere makes a complete circle round the vessel ; but a number of segments conjoined together, with their extremities turned off sidewise, seem to form one ring round the artery. These fibres, in the larger arterial trunks, form many strata, appear of a reddish colour, and are remarkably firm and solid ; but in the smaller arteries they are by degrees more difficult to demonstrate, and seem to be wanting in the arteries of small animals. Dr Haller has never observed them to run along the vessel lengthwise. Under these membranes, but pretty difficult to demonstrate, is an exceeding short cellular texture, into which a chalky concreting matter is poured when an artery ossifies.

The *innermost coat* of the artery is thin, and finely polished by the influent blood ; so as to form a single incrustation that every where lines the fleshy fibres, which are not very continuous one to the other, and prevents the blood from insinuating into the spaces betwixt them. It is every where smooth and without valves ; although, from a sort of mechanical necessity, sometimes certain folds, raised into a semicircle at the origination of branches, form a projecting eminence ; as we see at the branches produced by the arch of the aorta. Yet, in arteries of the viscera, the innermost coat is softer, lax, wrinkled, and almost friable, especially in the *ductus arteriosus*.

The arteries themselves *have arteries* which are more particularly spread through their external cellular coat ; and, springing on all sides from the next adjacent small arterial trunks, form numerous branchy net-works, which are all of them indeed very minute, but plainly appear, even in the *fœtus*, without injection, to be very numerous. There are also *nerves* which descend

for a long way together through the surface of the artery, and at last vanish in the cellular substance of the vessel; of which we have a specimen in the external and internal carotids and arch of the aorta ; and Dr Walter has shown them in numerous arteries in the thorax and abdomen. And from these, do not the arteries seem to derive a muscular and convulsive force, very different from that of their simple elasticity ? Does not this force show itself plainly enough in fevers, faintings, palsy, consumption, and passions of the mind ? Haller considers the artery as being in a manner insensible and unirritable ; and if it is constricted by the application of poisons, says he, it has this in common with the dead skin. This, however, is not agreeable to the opinions of the present physiologists.

The *sections*, or divisions, of arteries show themselves with a round cavity, because they are elastic ; and this is the reason why, from the small arteries of the teeth, hemorrhages are sometimes fatal. The aorta, indeed, of the thorax and abdomen, the carotids of the neck, and some other arteries of the dead body, from their lessened extension, appear somewhat flat or depressed ; but their round figure, or circular section, is every where restored by injection. *Their elasticity* is also evident in that powerful compression, which a segment of a large artery makes upon the finger that distends it, and which is much stronger in a dead than in a living body. In the living body, indeed, this force yields to that of the heart ; but instantly recovers itself when the heart is relaxed, and restores the artery to its former diameter ; and this makes the *pulse*, which all arteries possess, although the systole and diastole can be perceived by the finger, only in the larger, not in the smaller ones naturally ; and in the ultimate inflection of the arteries, the pulse totally vanishes ; but, by an increased motion of the blood, even the lesser arteries make a violent pulsation, as we see in an inflammation, or in pressure depending on an internal cause.

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These vessels strongly contract lengthwise, and are rendered shorter on dissection.

The strength of the arteries is considerable enough : but as the dense hard net-work of the outer cellular coat refuses to yield to a distending force, it breaks without much difficulty, almost easier than the coats of the veins ; and from thence arise aneurisms. But, in general, the trunks are, in all parts of the body, weaker, and the branches stronger, in their coats ; whence the impulse of the blood may exert a considerable effect upon the former, but least of all on those of the limbs. From hence it is, that aneurisms are most frequently formed near the heart ; for, in the lower extremities, the strength of the arteries, and of the veins too, is much increased, as well as in the secreting organs.

With regard to the course and general distribution of the arteries, nature has every where dispersed them through the whole animal body, except in a few membranes. But she hath disposed of the trunks every where in places of safety ; because wounds cannot happen to the smaller of them without danger, nor to the larger without loss of life. The skin is spread with numerous short and small arterial trunks ; but the larger ones, defended by the skin and muscles, creep along near the bones. In general, the arteries are in proportion to the parts of the body to which they are sent. The largest go to the secretory organs, the brain, and spleen ; the lesser ones to the muscular parts.

The proportion of the cavity of the artery to its solid part is not every where the same, nor is it constant even in the same artery. This proportion, in the first place, is least of all at the heart, and increases as the arteries remove farther from it. Secondly, in a full-fed plethoric animal, whose blood passes freely, and with great force through its arteries, the proportion of the solid parts of these vessels is less than in a famish-

ed extenuated creature, whose blood hath a feeble motion.

From the trunks of all the arteries branches are sent forth, and from these again proceed lesser twigs by a numerous division, of which you can scarce find the end, though you may perhaps count twenty subdivisions of this kind. Here the sections of any two branches taken together, always exceed that of the trunk from whence they come, in the proportion of three to two, or somewhat less. Also every trunk just above its division is somewhat broader or more expanded. The angles, at which the branches go out from their trunks, are generally acute, either half right angles or nearly so; to the forming of which angles, as we see in mechanics, there is required the longest projection. Instances of their going off at right angles, or nearly so, we have in the lumbar or intercostal arteries; of their going off in a retrograde or reflected course, we have one instance in the coronaries of the heart, and another instance in the spinal arteries, which are produced by the vertebrals. But, generally speaking, those which are esteemed retrograde or reflexed, were sent off, at their origin, in acute angles; such as the ascending artery of the pharynx, the descending one of the palate, the umbilical mammary arteries, and the nutritious ones of the large bones. Lastly, we often observe large branches arising under lesser angles, and smaller ones under greater angles: but it is rarely that we observe two arteries of a large diameter run together into one trunk. An example of this, however, we have in that artery which is formed out of the vertebrals: in the smaller ones it is frequent, as in both the spinal arteries, and that of the sincipital foramen. In many parts, the arteries have repeated alternate undulations or flexures, as they run on in a spiral course, wherein we see their diameter often considerably enlarged, as in the large intestines, womb, face, spleen, lips, and iris.

Even the straight arteries in other places, if too much distended, fall into serpentine flexures. Sometimes they are suddenly twisted into a kind of circles, as the carotids under the mamillary process.

The arteries are frequently conjoined by intermediate branches, in such a manner, that the twig of some certain artery shall run to meet one of the same kind from another neighbouring artery, and, by joining together with that, form one trunk. Instances of this kind we have among the large trunks in the intestines, among the middling ones in the kidneys, womb, &c. and among the smaller in all parts of the body; insomuch that there is no part of the human body, wherein the neighbouring arterial trunks, whether of the same or of different denominations, do not form anastomoses or joinings one to the other by intermediate branches. Of rings diverging laterally from the arteries, and returning into themselves, we have instances in the eye and brain. The extremities of the arteries, which are either cylindrical or nearly so, send off smaller branches, which, for their extent, are more numerous and generally disposed like a net; so that each branch, by its smaller twigs, forms anastomoses with those of its neighbouring branches: and thus we find it in all membranes. By this means it happens, that, though the passage from the heart to any part of an artery is obstructed, the blood may nevertheless flow through the neighbouring arteries into all the branches of the obstructed one. Thus a gangrene or languor of the part is very strongly prevented, and the obstruction is more easily resolved by the repulsion of the obstacle into the larger part of the trunk.

Lastly, one of the least arteries is either changed by a continuation of its canal into a vein, in such a manner, that the ultimate little artery, which is generally reflected, having surpassed the angle of its reflection, becomes now a small vein; or else a branch, sent out at right angles from the artery, is inserted under a like angle

angle into the branch of a small vein. Both these kinds of mechanism are demonstrated to us by the microscope, and the easy return of injections through the veins into the arteries. And these vessels we see sometimes large enough to receive only one, and sometimes several blood-globules at a time. A large artery is never observed to open into a vein.

In the viscera, we find the small arteries disposed not so much in net-works as in a different fabricature, wherein the small branches descend very thick, or in clusters, parallel to the trunk, so as to resemble brush-pencils, a variety of little trees or bushes, small serpents, or threads, according to the various disposition of the parts.

Sometimes the arteries end in another manner, namely, by being converted into vessels of the smaller kinds. These are sometimes continuous to the arteries and real arterial trunks, as may be observed in the ophthalmic artery, upon tracing the arteries of the tunica choroides, or the colourless ones of the circle of the uvea and iris. That a net-work of pellucid arteries is continuous with the red branches of the ophthalmic one, is evident from inflammations, and the redness of the parts when relaxed by vapour or by cupping; from repletion, and the microscopical experiments of Lieberkuhn upon frogs, in which colourless globules were seen to pass from a red artery into a lateral vessel. In a fabric of this kind the red blood is easily forced into the smaller vessels.

In other places the smaller vessels seem to proceed laterally as branches from the trunks of the least sanguineous arteries, and are drawn out into trunks still smaller. These are called *excretory ducts*. It is with difficulty that these vessels are filled with red blood; of this, however, we have examples in the kidneys, the liver, and breasts. Indeed the blood, when vitiated, penetrates the excretory ducts of the whole body, even without hurting the vessels; nor is that aber-

ration found to be productive of any evil consequence after the disorder of the blood is cured.

Another termination of the arterial extremities is into the exhaling vessels ; and this is a manner of their ending very frequently to be observed in all parts of the body. The whole skin, all membranes of the human body, which form any close cavity, all the ventricles of the brain, the anterior and posterior chambers of the eyes, all the adipose cells and pulmonary vesicles, the whole cavity of the stomach and intestinal tube, through which the air has a passage, are all of them replenished with exhaling arteries of this kind. These emit a thin, watery, gelatinous humour, which, being collected together by standing, sometimes makes no inconsiderable quantity ; and, particularly by disease or death, is converted into a watery, but coagulable lymph. The truth of this is easily demonstrable from the watery sweat that ensues after injecting the arteries with that liquor warm. In some places, indeed, they exhale not a thin vapour, but blood itself, as we see in the heart, the cellular fabric of the penis, urethra, clitoris, and nipple of the female breast ; in all which the blood itself is naturally poured out. Does not every secretion, that is made in true glands or hollow cryptæ, bear some analogy to this exhaling fabric ?

Whether or no, in all parts of the human body, do the pellucid vessels, arising from the sanguine ones, and carrying a humour thinner than blood, again send out smaller vessels, to be subdivided into still lesser orders ? We seem, indeed, not to want examples of this in the manner proposed to us by the most celebrated professors. Different anatomists have seen, in various parts of the body, a new rise of blood-vessels, after the course of the blood to the heart had been obstructed. That the aqueous humour is separated by very fine vessels, generated from the colourless arteries of the iris, is very probable. That the red-coloured vessels in the cortical

cortical substance of the brain, separate a juice pervading the medullary substance, by the intermedium of another order of vessels, we are almost certain. And the like we are persuaded from an erysipelas or yellow inflammation, arising from the yellow or serous globules impacted into smaller vessels.

It may then be asked, if there are not yellow arterious vessels of a second order, which send off lymphatic ones of a third order, from whence by degrees still lesser kinds of vessels branch out? Such a fabric does not seem agreeable to the very easy transition that is made by the blood, mercury, or wax, into the exhaling and perspiratory vessels, or into the uriniferous tubuli, with the adipose and pulmonary cells; nor is it very difficult for the blood to stray into the lactiferous, lymphatic and lachrymal ducts, whither it should seem not able to penetrate, if it went through any other intermediate vascular system smaller than the blood globules, which make the same journey. Nor can it be admitted, from the great retardation, which the humours must, in a third order of vessels, meet with from this mechanism, and which is continually to increase in proportion to their diminished size.

#### § I. *Of the common Offices of the Arteries.*

THE blood is driven from the left ventricle of the heart into the aorta; and here the mass of this purple fluid strikes first against the right side, and is then reflected to the left side of the aorta; whence flowing in a vortical or whirling motion as much as that full vessel will permit, it goes on through the arteries, with an alternate collision against, and repercussion from, their sides.

The arteries are, in a living person, always full of blood; since the jet or stream starts from an artery, is not interrupted by alternate stops, while the heart rests or relaxes itself, but it flows on in a continued thread;

add to this, that the microscope shows the arteries, in living animals, to be full, both in their systole and dia-stole; nor can the circular fibres of the arteries so far contract themselves as entirely to evacuate these tubes. Since, therefore, a new wave or column of blood is sent into the arteries, already full, although it bear a small proportion to the whole mass contained in the arterial system throughout the body, hardly ever exceeding two ounces; yet, by its immediate contact with the precedent wave or column, which moves slower as it gets farther from the heart, it consequently drives the same forwards, lengthens the artery, and makes it assume a cylindric form, augments its diameter, presses the membranes closer to one another, urges the convex parts of the arterial flexures outwards, and causes their spiral waves to be more serpentine, as injections demonstrate to us. This dilatation of the artery, whereby its light or capacity is changed from a less to a greater circle, is called the *pulse*; the dia-stole of which is an expansion of the artery beyond its natural diameter. This being the proper or characteristic action of life, results from the heart only, and is in nowise natural to the arteries left to themselves. Hence when the motion of the heart is intercepted, whether by a-neurism, ligature, or otherwise, there is no pulsation of the arteries to be felt; and hence there is a sudden cessation of the pulse, by a wound through the heart, in a living animal. But the artery is proportionally more dilated, as the wave of blood flows on before more slowly, and the more the velocity of the new wave exceeds that of the former one.

The systole or contraction of the artery follows the dilatation of it. For the heart having emptied itself, and removed the stimulus of the blood, comes into a state of relaxation and rest. But the artery, at this same time, by its innate elasticity and contractile power residing in its circular fibres, irritated likewise by the stimulus of the blood, contracts itself, and expels as much

much blood as served to dilate it beyond its mean or middle diameter : this quantity of blood is either forced into the smaller and scarce-beating arteriolæ, or into the veins, as the semilunar valves of the aorta oppose the return of the blood in the part of that vessel through which it has just now passed. So soon as the artery has freed itself from this wave or column of blood, being no longer stimulated by distention, it directly collapses by its own proper contractile force, and is now again ready to yield to a new wave or column of blood sent into it from the heart ; whence follows a repeated diastole.

That the arteries thus contract, and, by that force, propel their contained blood, is proved evidently from their strongly contractile nature ; from the apparent diminution of the diameter or dilatation they receive from the heart ; from the evacuation that follows, by the proper force of the artery itself, driving out all the blood that is contained in the lateral branches betwixt two ligatures ; from the return of the blood to the heart through veins whose artery is tied, which therefore the heart has no share in propelling ; from the wave of blood being greatest when the heart is in its diastole, as observed by some eminent anatomists ; from the strength with which the blood is ejected from the tied aorta below the ligature ; from the evacuation which the arteries make of their contained blood even after death into the veins, whereby these latter appear much fuller than the arteries ; and, lastly, from the considerable saltus of blood that issues from a large artery in an animal even after death, mounting to the height of two feet : to which add, the convulsive contractions of the animal in which the artery is thus wounded, and the remarkable closings of the mouths of divided arteries in wounds, and a sphacelation of the limbs from an ossification of the artery ; whence the veins become distended.

The mean swiftness of the blood's motion being diminished  
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minished in the time of the heart's systole, but increased during its diastole, is such as carries it through a space somewhat less than one foot in the space of a second of time; and the constant plenitude of the arteries renders it impossible for us to perceive any succession in the pulses of different arteries; whence all the arteries of the body seem to beat at one and the same instant, whilst the heart strikes against the breast: and yet there is certainly a succession in the systole of the arteries, by which the aorta seems to contract in the same order successively, as it is filled by the blood expelled from the heart; so that the part of the artery next the heart is first constricted, and thence gradually, the arterial contracting force proceeds to the extremities. An instance of this we have in the intestines; and the same is evident to the eye in insects, who have a long fistulous and knotted heart, manifestly contracting in a succession from the beginning to the end. But the mind cannot distinguish the least points of time, which are the measures of this succession, and amount only to a few thirds of a second.

If it be asked, Where this pulsation ends? we answer, In the least arteries, and cylindrical originations of the veins. We have already mentioned the velocity with which the blood comes from the heart. But that velocity continually decreases. Certain we are, (1.) That the sections of the arteries, composed by the aggregation or sum of their transverse sections, as they divide farther in their course from the heart, greatly exceed that of the aorta; so that since the ratio, or less proportion of the trunks to their branches, continually diminishes as they make less ramifications, and this in a variable or uncertain proportion; the difference of that ratio or proportion will be the greatest betwixt the light of the aorta at the heart, and the sum of the sections of all the small arteries, where they are least, in the extreme parts of the body. Again, (2.) The proportion of the arterial membranes or coats in thickness,

thickness, with respect to their bores or capacities, is greater as the arteries grow less ; and is largest in the least of them, which transmit only one globule at a time. The truth of this is proved from anatomy, and the forcing of air into the arteries, by which they burst always more difficultly as they are less ; and from the calculation itself, by which the magnitude of the least arteries is determined from the globules distending their two semicylindric membranes. Add to this, (3.) The friction of the juices through the least vessels, inflected and meeting together in angles ; which friction, even in the most fluid water, running through long pipes that are single, and in a direct course, greatly diminishes the velocity, and more in proportion as the tube is of a less bore ; while again, as the artery is less, there are a great number of globules rubbing and grating against its membranous converging sides. And by the conical figure of the artery, it happens, that the broader wave of blood, coming from the trunk, is resisted in its passage through the narrower branch, and so must distend it by force. But moreover, (4.) The inflections and folds, or plates of the vessels, greatly slacken the blood's motion ; since always some part of the impelling force is spent and lost in removing the convex parts of the folds, and changing the figure of the inflected vessel. The angles likewise take off more from this force in proportion to their acuteness, or the more they recede from a straight line. Lastly, (5.) A considerable allowance must be made for the great viscosity or tenacity of the blood itself ; since, by rest only, it directly hardens into clots ; and since it is from the circulatory motion only of the blood, that this mutual attraction of parts is overcome, so as to hinder it from adhering to the sides of the arteries ; for so we find it adhere in aneurisms and wounds of the arteries, or else the globules clot together, as we see usually after death. From all which considerations, you will observe, that the blood meets

with the greatest retardation in its course in the least vessels. And the opposition it meets with in the branches lessens the velocity of the blood also in the trunk : the opposition of torrents of blood to one another in the anastomoses of vessels also destroys some parts of its motion. We may easily perceive the amounts of this retardation will be very considerable, although it be difficult to estimate it justly. In the larger trunks the blood of a living animal flows with the rapidity of a torrent : but, in the least branches, it creeps along very slowly ; so that in these it begins to put on a state of coagulation. It is also well known to surgeons, that a small branch of an artery near the heart or aorta bleeds more dangerously than a much larger one that lies at a greater distance. The weight of the incumbent atmosphere, of the muscles and fleshy parts lying above the artery, and the contractile power of the vessel itself, make a resistance indeed to the heart ; but do not lessen the velocity of the blood, seeing they add as much in the diastole as they diminish in the systole.

It is certain, however, from incisions made in living animals, that the single globules of blood, which move separately in the small vessels, do not lose so much of their velocity as, by calculation, they ought to do. We must therefore assign some causes by which this power, destructive of the blood's motion, is lessened. And, in the first place, it is certain, that the lights of the branches do not bear such a proportion to the trunk in the smallest vessels ; their great smoothness diminishes the friction. The facility likewise with which the blood flows through the veins, expedites its passage through the little arteries, which immediately communicate with these veins. No great help is to be expected from considering the effect of ligatures or the weight of the blood, which is capable both of diminishing and accelerating the motion ; nor can we suppose that in live animals a great effect depends upon

the force of the nerves. The power of derivation, whatever that is, and the motion of the muscles, are capable of producing a new velocity.

The pulse therefore ensues, because the anterior wave or column of blood moves on slower, while the subsequent or posterior wave comes faster; so that the preceding is an obstacle to the consequent blood. But since the force of the heart weakens as the blood goes on, and the contractile power of the arteries increases, therefore the disproportion of celerity betwixt the antecedent and consequent waves or columns of blood coming from the heart, will be continually lessening with respect to the blood that is urged on by the contraction of the smaller vessels, till arriving at a part where there is no excess or difference, it will there cease to make any pulsation of the artery; because here the anterior and consequent blood flow evenly, or with the same celerity. But this place of equality in motion cannot be in the larger and more conspicuous arterial branches: for in them the wave, last coming from the heart, moves quicker than what went before; as is evident from the inflammatory pulsation of them, especially in the small arteries of the eye. But, in the least red arteries, the pulse at length begins to vanish. This is evident from the equable motion of the blood, often seen by a microscope through the arteries of a frog. In the larger vessels, however, such as may be about the sixth part of a line in diameter, the pulse is perceptible. But in the least veins visible to the eye, there is no sensible pulsation or accelerated motion of the blood, whilst the heart contracts, demonstrable either by the microscope or any other experiment.

Even in the veins, the blood presses against their sides, as appears from the furrows hollowed out of the bones, and the swelling of the veins on being tied. If it be asked, Why the veins do not beat? (for we do not allow that to be a pulse which happens from respiration, from the rejection of the blood from the right auricle,

auricle, or from the muscular part of the vena cava); the reason of this seems to be, that the blood, immediately on its leaving the heart, is more retarded in its motion than when it passes into the smallest vessels. Hence, the short space of time by which the velocity of the last wave exceeds the foregoing, is greatest at the heart, and grows gradually less, till it at last totally vanishes. This is illustrated by the experiment, in which a pipe, fixed in a leathern tube, and driving forth water in a continual, but starting stream, does, by a sponge fixed round the mouth of the said tube, cause the water to issue forth in an even stream, without leaping through the sponge; and the same is evident from another experiment, in which the same thing happens, by injecting the mesenteric arteries with an alternate impulsion of water; for then the water flows out through the veins in one continued even stream.

The pulse is therefore the measure of the powers which the heart spends on the blood; because it is the immediate and full effect of those powers. Hence, all things considered as alike, the pulse is slow in the most healthy people, where there is no stimulus, nor any unnatural resistance to cause the effect of a stimulus, but the heart is at liberty to send forwards the blood with ease. You must except those cases where there is some obstacle, by which the blood is prevented from entering the aorta. For this reason the pulse in asthmatic people is slow: the same thing also happens from a debility or insensibility of the heart, which the usual stimulus is not capable of exciting to contraction. A large pulse is caused by fulness of the artery, joined with a strong force of the heart; a small pulse by the emptiness of the artery, and a lesser wave of blood sent from the heart. A hard pulse denotes some obstacle or stimulus; or else that the heart's force is increased with a greater thickness of blood, or a greater rigidity of the artery. A quick pulse denotes some stimulus, obstacle, or greater sensibility or irritability of

of the heart. It is best felt where the artery lies exposed bare to the touch, upon some resisting bone ; but obstructions sometimes render the pulse perceptible, where it is never so naturally.

The pulse is slower in animals as they are larger or more bulky ; because the heart is proportionably bigger in the smaller than in the larger animals, and, as well as the other parts of the body, is more irritable in the former than in the latter ; and because the heart is obliged to drive the blood to a greater distance ; whence the resistances or frictions in the more bulky seem to be increased more than the force of the heart. Hence, small animals are more voracious ; and large ones, as the whale and elephant, eat less. The pulse of a healthy person rising in the morning, beats 65 in a minute ; but, after the fatigue of the day, it will beat 80 in that time ; and again, by the night's rest or sleep, it will become gradually less frequent, till in the morning you will find it returned to its primitive number of 65. For the motions of the muscles, and actions of the external and internal senses, the warmth of the atmosphere, and the action of the aliments taken into the stomach, urge the venal blood on to the heart, which being thereby oftener stimulated, makes more frequent contractions. This is the cause of those paroxysms or fits of increase observable in all fevers towards the evening. For sleep not only retards the motion of the blood, but of all the other humours and actions in the body whatever.

A frequent pulse is different from a swift one ; and it is possible for the pulse to be at the same time swift and unfrequent. But it is difficult to observe a swift pulse. The frequent pulse is what is commonly called a swift one. It takes place in children, and becomes afterwards slower in persons as they grow older. The salient point beats 134 in a minute : new-born infants have their pulse 120 in that time ; and from thence down to old age it grows slower, to 60 in a minute.

A feverish pulse begins from 96 per minute; and we count the pulse has but a moderate celerity in fevers, or laborious exercises of adult persons, if it does not exceed above 110 or 120 in a minute: but it is excessive at 130 or 140, with which number people seldom recover; nor have we ever observed it exceed that number. The pulse beats slower in winter, and quicker in summer, by about 10 strokes per minute; and under the torrid zone, it grows quicker to 120. The different passions of the mind variously accelerate, retard, and disturb the pulse. Whatever obstructs the circulation is also found to accelerate the pulse; not from the laws of hydrostatics, or on account of the canal being made narrower, nor from the action of the soul; but only the heart, being with more difficulty freed from the stimulating, contracts itself more strongly, and at shorter intervals. An irritation from an acrid blood is the cause of the frequent pulse in fevers.

Through the least veins the blood moves on very slowly, partly by force of the heart, and partly by the contractile force of the arteries. The first is proved by a renewal of the motion of the blood in persons drowned; where, merely by exciting the action of the heart, the whole mass is again propelled. But the contractile force of the artery is proved by what has been said above. But after death the blood continues to move, in part, also by its own gravity, and by the elasticity of the air generated or extricated by putrefaction.

But the blood moves on faster in the larger veins. For whenever the impelling powers remain sufficient, and the conveying small vessels are rendered narrower, the motion of their contained fluids must of course be accelerated; since the section of the venal trunk is much less than that of all its branches, in the same manner as that of an artery is less than the sum of the branches into which it divides. Therefore if the mo-

tion of the venal blood loses nothing in its way, the proportion of its celerity in the vena cava, to its celerity in the veins of the thirtieth division, will be thirty times greater in the former, in proportion as the conjunct sections of all the small veins exceed the section of the cava. In like manner, too, the friction or attrition of the blood in the veins, and its contact with their sides, diminish.

But since the blood moves thus slowly in the least arterial vessels and incipient veins, and as the weight of the blood itself in many places wonderfully hinders its return to the heart, while, at the same time, the very thin coats of the veins have but little contractile power to be expected from them; therefore nature has used various precautions, lest, from the slowness of its motion, it should anywhere stagnate or concrete. To obviate this, she has supplied the veins with more watery vapours and fluxile lymph, than she probably sent by the arteries, if we consider the great exhalation that is made from the arterial blood in the lungs.

She has, therefore, likewise placed the veins near the muscles, that by the turgescence or contractions of the latter the veins may be pressed; and since any pressure upon the veins must be determined towards the heart, therefore all this force must be entirely employed in accelerating the return of the blood to the heart. From hence proceeds that wonderful quickness of the pulse, heat, and redness of the body, with a short and laborious breathing, that attend muscular motions or violent exercises.

Moreover, those muscles which constantly urge or press violently the contiguous viscera on all sides that are contained in any of the common cavities, do all of them powerfully promote the return of the venal blood to the heart. Such an effect has the conjunct pressure of the diaphragm with the abdominal muscles, in respect to the abdomen. Lastly, the pulsations of the arteries, which run every where contiguous and parallel

to the sides of the veins, have no inconsiderable effect in promoting the return of the venal blood; since, as we have before shown, any impulse acting on the veins can determine their blood to the heart only.

To these is added a force not yet sufficiently known, by which the blood is brought from a place where it is more compressed to one more lax, and where it meets with less resistance. In this matter also respiration is of great efficacy; in which the motion of the blood into the lungs, when relaxed, is accelerated by the power of derivation from all parts of the body: and again, in exspiration, it is driven into the trunks of the veins in the head and abdomen. Hence the swelling of the veins, and likewise of the brain, in the time of exspiration. The circulation is not indeed assisted by these causes, but the blood is agitated and pressed. The anastomoses of the arteries contribute to the same end; for they render the passage of the blood more easy from those places where it is obstructed to such as are more free.

By these means, the blood in a healthy person, using sufficient exercise of body, moves on with such a velocity, as suffices to deliver as much of the purple fluid in every pulse by the vena cava to the heart, as is equal to what is sent out by that great artery the aorta. But rest or inactivity of body, and a weakness of the contracting fibres of the heart and other muscles, frequently render this motion of the venal blood more difficult. Hence follow the varices and the piles in women with child; which latter is much occasioned from the deficiency of valves in the vena portarum. And from hence spring even the menses themselves. And when the veins too slowly return their blood to the heart, the subtle vapours, being thus unable to return to the heart, are obliged to stagnate; whence proceeds that frequency of œdematosus and pitting swellings of weak people.

The time in which an ounce of blood, sent out from  
the

the left ventricle of the heart, returns to the right, and which is commonly reckoned the time in which the greater circulation is performed, is uncertain, and different in every different portion of the body. If, however, you want to know about the ounce of blood propelled in that quantity, which we have mentioned, the amount of it will be about  $7\frac{1}{2}$  ounces in an hour with 4500 pulses; and the amount of the perfect circulations will be about  $23\frac{1}{2}$ .

The effects which follow from the motion of the heart and arteries upon the blood are various; which may be deduced and estimated from the causes themselves of those effects, if we compare the blood of a living and of a dead animal, that which is healthy with that which is diseased, and that which is inert or too little moved with that which circulates too swiftly. For we observe that, in the living, the blood is, (1.) Considerably warm or hot. (2.) It looks red, with a sort of purple florid hue. (3.) It seems to be homogeneous or uniform, and alike in its parts; though they are really mixed and of different principles. (4.) It is made up almost entirely of particles, commonly called globules. (5.) It flows very readily through the least vessels: From whence being drawn, (6.) It exhales a volatile vapour, which we have already described particularly. In the dead animal which has not yet begun to corrupt or putrefy, we observe, (1.) That it has lost a great deal of its redness. (2.) That it separates into a more dense and a more thin substance. (3.) That it exhales no vapour. (4.) Being drawn out from the veins, it congeals all or the greatest part. But even in the living animal, when very weak, where there is some pulse or respiration, though small, we find the blood cold, even to a considerable degree. If, again, you compare the blood of a human person, unactive both in body and mind, with the blood of one that is addicted to violent exercise, you will observe the latter has, (1.) A greater heat. (2.) A more intense redness.

(3.) A substance more compact, and specifically heavier. And, (4.) The volatile parts more abundant. All which appearances seem manifestly the effects of the motion of the heart and arteries, since they proportionably increase and diminish with that motion, and disappear when that ceases.

That we may understand the manner in which these appearances are produced in the blood, we must consider what are the effects of the heart impelling the same, and of the arteries alternately compressing and urging it forward. And first we see, that the heart drives the blood into the arteries with a very great celerity. With a confused or vortical motion, the heart thus throws the blood into the crooked or inflected arteries, in such a manner that the right globules, expelled through the opening of the aorta, strike against the left side of the artery; from whence being repelled, they incline towards the right side, whereby all the particles of the blood are agitated with a confused or turbulent and whirling motion. The blood thus impelled against the flexible and curved sides of the arteries, of necessity dilates or distends them into a greater convexity; and, lastly, in the smaller vessels, capable of receiving only one or a few of the blood-particles, all the said particles come so intimately into contact with, and grate against, the sides of the said artery in all their points, that they are even obliged to change their figure in gaining a passage into the veins.

But the arteries, by their elastic force, reacting upon the impinging blood, repel the same from their sides towards the axis of the light or capacity; and at last transmit every single particle of it through the circular mouths of the least vessels, by which the arteries and veins join together.

There is, therefore, a most prodigious degree of friction, as well from the blood particles upon the sides of the arteries as from the arteries themselves contracting round the blood; to which add, the attrition

tion of the particles of blood against each other by the confused and vortical motion with which they are propelled. The effects of this friction may be computed from the viscid and inflammable nature of the blood itself, from the narrowness of the vessels through which it runs, and from the strong impulse of the heart, joined with the powerful reaction of the arteries; to which add, the weight of the incumbent parts raised by the force of the arterial blood. This friction generates a fluidity in the blood, by perpetually removing the points of contact in its particles, resisting their attraction of cohesion, mixing together particles of different kinds, which become more fluid upon mixture, as we have an instance in oil when triturated with water. It also augments the roundness of the particles, by breaking off their protuberances and little branchings. But even these very small particles themselves, which are broken off from the large particles of the blood, put on a round figure by their friction against the sides of the canals, and by their rotatory motion: By deficiency in these particulars the blood coagulates in the vessels before death; and hence the lost fluidity of the blood is again restored by recovering the motion of the heart, as we are taught by experiments made on living animals. It is a question, whether this motion of the blood, and the density proceeding from it, is the cause of the red colour of the blood, seeing the redness is in proportion to the density, and increases or decreases from the same causes. This seems to arise from a mixture of the ferruginous with the oily part of the blood.

We may also ask, whether the heat of the blood does not also proceed from its motion? seeing we observe heat to arise from the motion of all kinds of fluids, even of air itself, in our experiments; but much more does this attrition produce heat in the inflammable animal juices, which are denser than water, and compressed with a considerable force by con-

tractile and converging tubes. Is not the truth of this sufficiently evinced, by the blood's being warm in those fish which have a large heart, and cold in such as have a small one? the generation of heat being in proportion to the size of their bodies: from the more intense heat of birds that have a larger heart, and more frequent or quick pulsations? from the increase of animal heat, that ensues from exercise of all kinds, and even from bare friction of parts? from the conge-  
lation of all the humours of the human body in a cer-  
tain degree of cold, in which a man grows stiff, tho'  
he yet retains some warm blood and is alive? and  
from the coldness of such people as have their pulse  
weak and obscure? Nor does the heat at all arise at  
first from any degree of putrefaction in the blood,  
seeing the humours themselves, when left at rest, ge-  
nerate no heat. Nor must we explain an evident ap-  
pearance from the action of such an obscure being as  
the *vital power*; and though sometimes the heat may  
be greater when the pulse is slow, and less when it is  
more frequent, the difference may arise from the dif-  
ferent disposition of the blood, from the different den-  
sities of the vessels, or the increase or diminution of  
perspiration.

The same cause also hinders putrefaction, by not suffering the intestine motion to be diminished, and by dissipating such particles as have already begun to be corrupted.

But the different natures of the several particles themselves, which conjunctly make up the mass of blood, are the causes by which, from one and the same impetus of the heart, different effects or conse-  
quences are produced in different particles of the blood; namely, those particles move quicker, whose greater density makes them receive a greater impetus, and whose apt figure or less extended surface makes them meet with less resistance in the fluid in which they move. Those also are driven along more swiftly  
which

which, either from their weight, or from the direction in which they pass out from the heart, are urged chiefly into the axis of the vessel. Those again will strike against the convexities of the flexures in the arteries, which have the greatest projectile motion; while the other parts of greater bulk and tenacity, having less projectile motion, will move sluggishly along the concavity of the vessel. And in this manner is the blood prepared or disposed for the several secretions.

The systole of the arteries renders the parts of their contained fluids more dense or compact, while they contract round the blood as round a solid obstacle; which being in some parts viscid and compressible, they drive and expel the more liquid parts into the lateral mouths or ducts, at the same time increasing the points of contact betwixt the particles themselves, combining their more large and dense particles, and compacting the flat particles into denser bodies. But the density of the blood is partly as the number of particles, and partly as the density of the materials whereof these particles are composed.

Moreover, the mouths of the least vessels pervious to only one particle at a time, seem to be a sort of moulds to figure and break off the angular eminences of the particles in the blood, and bring them to a circular figure; which at length they put on, and change into perfect circles, which, according to the observations of Mr Hewson, are flat like a piece of money.

The reticular distributions and inosculations of arteries remove any danger of obstruction; since in any part of the artery where the blood cohering begins to form an obstruction, a contrary flux is admitted, by which the obstructing matter is repelled to a larger part of the trunk; and thus betwixt the reflux and the direct torrent of the blood, the said matter is broken and attenuated. This mechanism also supplies the

deficiency from an irremovable obstruction or the loss of a vessel, by causing a greater distension or enlargement of the next adjoining or anastomosing vessel ; as is proved by experience in surgery, after tying and cutting a great artery. The collision of these opposite torrents of blood take something from its velocity ; and the reticular distribution augments the friction of the particles.

As the quicker motions of the blood in the trunks conduce to sanguification, so the slower motions of it, in the least vessels, have their effects towards the secretions. In the larger arteries we see the different particles of the blood are whirled about amongst each other with a rapid and confused motion ; but, in the lesser ramifications, the progressive motion of the blood being diminished, the more loose colourless particles depart laterally from the more dense and red particles ; while the latter, keeping on their course more firmly along the axis of the vessel, expel the former laterally, and to the circumference. Thus the attractive powers of the particles of the blood increase as their progressive motion abates : hence the oily or fat particles are drawn one to another, and go off by the open lateral ducts that lead to the cellular substance ; which particles we know are both gross and sluggish : and again, other thinner juices are sent off through lateral branches of a much smaller orifice, till at length little more than the red blood alone remains to pass through the coalescent artery into the incipient vein ; But all these particulars, by which the blood is disposed for the secretions, we shall consider in another place.

### § 2. Of the particular Arteries.

*Introduction.* THE heart throws the blood into two great arteries ; one of which is named *aorta*, the other *arteria pulmonalis*.

The aorta distributes the blood to all the parts of the body,

body, for the nourishment of the parts, and for the secretion of different fluids.

The arteria pulmonalis carries the venal blood thro' all the capillary vessels of the lungs.

Both these great or general arteries are subdivided into several branches, and into a great number of ramifications.

*The pulmonary artery.* The pulmonary artery goes out from the right ventricle of the heart; and its trunk having run almost directly upward as high as the curvature of the aorta, is divided into two lateral branches, one going to the right side, called the *right pulmonary artery*; the other to the left side, termed the *left pulmonary artery*. The right artery passes under the curvature of the aorta, and is consequently longer than the left. They both run to the lungs, and are dispersed through their whole substance by ramifications nearly like those of the bronchia, and lying in the same directions. From the pulmonary arteries the blood is returned by the veins; which, contrary to the course of the arteries, begin by very minute canals, and gradually become larger, forming at length four large trunks called *pulmonary veins*, which terminate in the left auricle from whence the blood passes into the left ventricle. From this the aorta goes out in a direct course, nearly over-against the fourth vertebra of the back. Its course is direct with respect to the heart; but with respect to all the rest of the body, it ascends obliquely from the left to the right hand, and from before, backward.

Soon after this, it bends obliquely from the right hand to the left, and from before, backward, reaching as high as the second vertebra of the back; from whence it runs down again in the same direction, forming an oblique arch. The middle of this arch is almost opposite to the right side or edge of the superior portion of the sternum, between the cartilaginous extremities or sternal articulations of the first two ribs.

From thence the aorta descends in a direct course a-

long the anterior part of the vertebræ, all the way to the os sacrum, lying a little toward the left hand ; and there it terminates in two subordinate or collateral trunks, called *arteriæ iliacæ*.

*General division of the aorta.* The aorta is by anatomists generally divided into the aorta ascendens and aorta descendens, though both are but one and the same trunk. It is termed *ascendens*, from where it leaves the heart to the extremity of the great curvature or arch. The remaining part of this trunk from the arch to the os sacrum or bifurcation already mentioned, is named *descendens*.

The aorta descendens is further divided into the superior and inferior portions ; the first taking in all that lies above the diaphragm ; the other, all that lies between the diaphragm and the bifurcation.

The aorta ascendens is chiefly distributed to part of the thorax, to the head and upper extremities. The superior portion of the aorta descendens furnishes the rest of the thorax ; the inferior portion furnishes the abdomen and lower extremities.

The great trunk of the aorta, thro' its whole length, sends off immediately several branches, which are afterwards differently ramified ; and these arterial branches may be looked upon as so many trunks with respect to the other ramifications, which again may be considered as small trunks with regard to the ramifications that they send off.

The branches which go out immediately from the trunk of the aorta, may be termed *original* or *capital branches* ; and of these some are large, and others very small.

The large capital branches of the aorta are these : two arteriæ subclaviæ ; two carotides, one cæliaca, one mesenterica superior, two renales, formerly termed *emulgentes*, one mesenterica inferior, and two iliaca.

The small capital branches are chiefly the arteriæ coronariæ cordis, bronchiales, œsophagææ, intercostales, dia-

diaphragmaticæ inferiores, spermaticæ, lumbares, and sacræ.

These capital branches or arteries are for the most part disposed in pairs; there being none in odd numbers but the cæliaca, the two mesentericæ, some of the œsophagææ, the bronchialis, and sometimes the sacræ.

The ramifications of each capital branch are in uneven numbers with respect to their particular trunks; but with respect to the ramifications of the like capital trunks on the other side, they are disposed in pairs. Among the branches there are in odd numbers, none but the arteria sacra when it is single, and the œsophagææ, the ramifications of which are sometimes found in pairs.

Before we enter upon the detail of each of these particular arteries, many of which have proper names; it will be convenient to give a short view of the disposition and distribution of the principal arterial branches, as a general plan to which all the particularities of each distribution may afterwards be referred: for we have found by experience, that the common method of describing the course of all the ramifications of these vessels, without having first given a general idea of the principal branches, is very troublesome to beginners.

From the upper part of the arch or curvature, the aorta sends out commonly three, sometimes four, large branches, their origins being very near each other. When there are four, the two middle branches are termed *arteriæ carotides*; the other two, *subclaviae*; and both are distinguished into right and left.

When there are but three branches, which is oftenest the case, the first is a short trunk, common to the right subclavian and carotid; the second is the left subclavian; and the third the left carotid. Sometimes, though very rarely, these four arteries unite in two trunks.

The origin of the left subclavian terminates the aorta ascendens; but we have sometimes observed four branches,

branches, the first three of which were those already mentioned, and the fourth a distinct trunk of the left vertebral artery.

It must be observed, that these large branches which arise from the curvature of the aorta, are situated obliquely; the first, or that which is most on the right hand, lying more forward than the rest, and the last, which is most on the left hand, more backward. The first and second, or middle branches, are generally in the middle of the arch, and the third lower down. Sometimes the first alone is in the middle; all which varieties depend on the obliquity of the arch.

The carotid arteries run up directly to the head, each of them being first divided into two, one external, the other internal. The external artery goes chiefly to the outer parts of the head and dura mater, or first covering of the brain. The internal enters the cranium through the bony canal of the os petrosum; and is distributed through the brain by a great number of ramifications.

The subclavian arteries separate laterally and almost transversely, each toward that side on which it lies, behind and under the clavicolæ, from whence they have their name. The left seems to be shorter, and runs more obliquely than the right.

The subclavian on each side terminates at the upper edge of the first rib, between the lower insertions of the first scalenus muscle: and there, as it goes out of the thorax, takes the name of *arteria axillaris*.

During this course of the subclavian artery, taking in the common trunk of the right subclavian, several arteries arise from it, viz. the *mammaria interna*, *mediastina*, *pericardia*, *diaphragmatica minor* five superior, *thymica*, and *trachealis*.

The *thymica* and *trachealis* on each side are in some subjects only branches of one small trunk which springs from the common trunk of the right subclavian and carotid.

They

They are generally small arteries, which run sometimes separate, and sometimes partly separate and partly joined.

The subclavian sends off likewise the *mammaria interna*, *vertebrales*, *cervicales*, and sometimes several of the upper *intercostales*.

The axillary artery, which is only a continuation of the subclavian, from where it goes out of the thorax to the axilla, detaches chiefly the *mammaria externa* or *thoracica superior*, *thoracica inferior*, *scapulares externæ*, *scapularis interna*, *humeralis* or *muscularis*, &c. Afterwards it is continued, by different ramifications and under different names, over the whole arm, all the way to the ends of the fingers.

The superior portion of the aorta descendens gives off the *arteriæ bronchiales*, which arise sometimes by a small common trunk, sometimes separate, and sometimes do not come immediately from the aorta. It next sends off the *œsophagææ*, which may be looked upon as *mediastinæ posteriores*; and then the *intercostales* from its posterior part, which in some subjects come all from this portion of the aorta, in others only the lowest eight or nine.

The small anterior arteries here mentioned are generally, at their origins, single and in uneven numbers, but they divide soon after toward the right and left.

The inferior portion of the descending aorta, as it passes through the diaphragm, gives off the *diaphragmaticæ inferiores* or *phrenicæ*, which however do not always come immediately from the aorta. Afterwards it sends off several branches anteriorly, posteriorly, and laterally.

The anterior branches are *cæliaca*, which supply the stomach, liver, spleen, pancreas, &c.; the *mesenterica superior*, which goes chiefly to the mesentery, to the small intestines, and to that part of the great intestines which lies on the right side of the abdomen; the *mesenterica inferior*, which goes to the great intestines on the

the left side, and produces the *hæmorrhoidalis interna*; and lastly, the right and left arteriæ spermaticæ.

The posterior branches are the arteriæ lumbares, of which there are several pairs, and the sacræ, which do not always come from the trunk of the aorta.

The lateral branches are the capsulares and adiposæ, the origin of which often varies; the renales, formerly termed *emulgentes*, and the iliacæ, which terminate the aorta by the bifurcation already mentioned.

The iliac artery on each side is commonly divided into the external or anterior, and internal or posterior.

The internal iliaca is likewise named *arteria hypogastrica*; and its ramifications are distributed to the viscera contained in the pelvis, and to the neighbouring parts, both internal and external.

The iliaca externa, which is the true continuation of the iliac trunk, and alone deserves that name, goes on to the inguen, and then out of the abdomen, under the ligamentum Fallopii; having first detached the epigastrica, which goes to the musculi abdominis recti. Having quitted the abdomen, it commences arteria cruralis, which runs down upon the thigh, and is distributed by many branches and ramifications to all the lower extremity.

We shall now go on to examine particularly all the capital or original branches of the aorta, from their origin to the entry of them, and of their ramifications into all the parts of the body, and all the different viscera and organs.

*Arteriæ cardiacæ sive coronariæ cordis.* The cardiac or coronary arteries of the heart, arise from the aorta immediately on its leaving the heart. They are two in number; and, according to the natural situation of the heart, one is rather superior than anterior, the other rather inferior than posterior.

They go out near the two sides of the pulmonary artery; which having first surrounded, they afterwards run upon the basis of the heart in form of a kind of crown

crown

crown or garland, from whence they are called *coronariae*; they first run between the auricles, and then pursue the superficial traces of the union of the two ventricles, from the basis of the heart to the apex.

They send communicating branches to each other, which are afterward lost in the substance of the heart. The right artery, after running between the auricle and ventricle of that side, sends branches to the pulmonary artery, to the fat surrounding it, and to the beginning of the aorta; then it gives three branches to the convex side of the heart, and as many to the flat surface. The left artery runs between the pulmonary artery and left auricle, and afterwards divides into branches, one of which is anterior, and runs down sending off branches that reach the point of the heart: some of these are reflected upon the flat surface so as to communicate with the branches of the right trunk; another branch runs between the left auricle and ventricle, to the obtuse side of the heart, and then to its flat surface, where it is lost in the substance of the left ventricle; but sends branches likewise to the left auricle and pulmonary veins; and here it communicates with branches of the trunk on the right side.

We sometimes meet with a third coronary artery, which arises from the aorta more backward, and is spent on the posterior or lower side of the heart.

*The arteriae carotides in general.* These arteries are two in number; one called the *right carotid*, the other the *left*. They arise near each other, from the curvature or arch of the aorta; the left immediately, the right most commonly, from the trunk of the subclavia on the same side, as has been already observed.

They run upon each side of the trachea arteria, between it and the internal jugular vein, and behind the musculi platysma, myoides, and sternocleido-mastoides, as high as the larynx, without any ramification. During this course, therefore, they may be named *carotid trunks*, or *general, common, and original carotids*.

Each

Each of these trunks is afterwards ramified in the following manner.

The trunk which sends off no branches till it has reached as high as the larynx, is divided into two particular carotids; one named *external*, the other *internal*; because the first goes chiefly to the external parts of the head, the second enters the cranium, and is distributed to the brain.

The *external carotid* is anterior, the *internal posterior*; and the *external* is even situated more inward and nearer the larynx than the other; but the common names may still be retained, as being taken, not from their situation, but from their distribution.

*Arteria carotis externa.* The *external carotid* is the smallest, and yet appears by its direction to be a continuation of the common trunk. It runs insensibly outward, between the external angle of the lower jaw and the parotid gland, which it supplies as it passes. Afterwards it ascends on the foreside of the ear, and ends in the temples.

In this course it sends off several branches, which may well enough be divided into anterior or internal, and posterior or external; and the principal branches of each kind are these.

The first anterior or internal branch goes out from the very origin of the carotid on the inside; and having presently afterward taken a little turn, and sent off branches to the jugular glands near it, to the fat and skin, it runs transversely, and is distributed to the glandulæ thyroidææ, and to the muscles and other parts of the larynx; for which reason it may be called *laryngææ*, or *gutturalis superior*. It likewise sends some branches to the pharynx and muscles of the os hyoides.

The second anterior branch passes over the nearest cornu of the os hyoides to the muscles of that bone and of the tongue; and to the glandulæ sublingualis; afterwards passing before the cornu of the os hyoides, it loses itself in the tongue; from whence it has been called

called *arteria sublingualis*; and it is the same artery which others have named *ranina*. That part of the artery which goes commonly by this name lies at the inferior and lateral part of the tongue, and is accompanied by a large vein.

The third branch, or *arteria maxillaris inferior*, and *pharyngea inferior* of Sabatier, goes to the maxillary gland, to the styloide and mastoide muscles, to the parotid and sublingual glands, to the muscles of the pharynx, and to the small flexors of the head.

The fourth branch, which Winslow, &c. names *arteria maxillaris externa*, and which Haller and Sabatier call *arteria labialis*, is at first covered by the stylo-hyoid and diahyal muscles: in its passage it sends branches to the pharynx, to the tongue, amygdala, and palate; at the angle of the jaw it gives branches to the skin, muscles, glands, &c. in the neighbourhood of that bone. Afterwards it runs over the lower jaw, before the inferior edge of the masseter muscle, and then gets under the *musculus depressor angulioris*, which it supplies, as well as the *buccinator* and the *depressor labii inferioris*.

It sends off a particular branch, very much contorted, which divides at the angular commissure of the lips; and running in the same manner along the superior and inferior portions of the *musculus orbicularis*, it communicates on both sides with its fellow, and thereby forms a kind of *arteria coronaria labiorum*.

Afterwards it ascends towards the nares, and is distributed to the muscles, cartilages, and other parts of the nose, sending down some twigs which communicate with the coronary artery of the lips. Lastly, it reaches the great angle of the eye, and is ramified and lost on the *musculis orbicularis palpebrarum*, *superciliaris*, and *frontalis*. Through all this course it is named *arteria angularis*.

The fifth branch, called *maxillaris interna*, arises over-against the condyle of the lower jaw, and is very considerable.

considerable. It passes behind the condyle, and runs between the jaws, where it gives off numerous branches to the parts which lie near it. The most considerable of these are, (1.) The spheno-spinalis, or media duræ matris, which runs between the internal and external carotids : this passes through the foramen spinale of the sphenoidal bone, and is distributed to the dura mater by several ramifications, which run forward, upward, and backward ; the uppermost communicating with those on the other side above the longitudinal sinus of the dura mater. This artery of the dura mater may be termed *spheno spinalis*, or *media duræ matris*, to distinguish it from those that go to the same part by another course. (2.) The maxillaris inferior, which runs through the canal of the lower jaw ; and being distributed to the alveoli and teeth, goes out at the hole near the chin, and loses itself in the neighbouring muscles, communicating with the branches of the arteria maxillaris externa. (3.) The pterygoideæ, and temporales profundæ, to the pterygoid and temporal muscles. (4.) The arteria buccalis, to the buccinator muscle, and other soft parts of the cheek. (5.) The alveolaris, to the teeth and substance of the upper jaw, and to several of the soft parts surrounding it. (6.) The infra-orbitaria, which, after sending a branch to the nose, passes through the posterior opening of the orbital canal ; and having sent branches to the orbit, antrum maxillaris, and teeth, goes out by the infra orbital hole, and on the cheek communicates with the angular artery. (7.) Palatina superior, which goes through the palato-maxillary canal to the palate and bones surrounding it. Another small branch terminates on the parts at the upper end of the pharynx.

The sixth anterior or internal branch, which is very small, is spent on the muscle masseter.

The first external or posterior branch is named *arteria occipitalis*. It passes obliquely before the internal jugular vein ; and having given twigs to the *musculus stylo-*

stylo-hyoidæus, stylo-glossus, and digastricus, it runs between the styloide and mastoide apophyses, along the mastoide groove, and goes to the muscles and integuments which cover the os occipitis, turning several times in an undulating manner as it ascends backwards.

It communicates by a descending branch with the vertebral and cervical arteries, as has been already said, near the top of the head; it communicates likewise with the posterior branches of the temporal artery, and it sends a branch to the foramen mastoïdæum.

The second external branch spreads itself on the outward ear, by a great many small twigs on each side, several of which run inward, and furnish the cartilages, meatus auditorius, skin of the tympanum, and internal ear.

The trunk of the external carotid ascends afterward above the zygoma, passing between the angle of the lower jaw and parotid gland, and forms the temporal artery, which divides into an anterior, middle, and posterior branch.

The anterior branch of the temporal artery goes to the musculus frontalis, communicates with the arteria angularis, and sometimes gives off a very small artery, which pierces the internal apophysis of the os malæ all the way to the orbit. The middle branch goes partly to the musculus frontalis, partly to the occipitalis. The posterior branch goes to the occiput, and communicates with the arteria occipitalis. All these branches likewise furnish the integuments.

*Arteria carotis interna.* The internal carotid artery leaving the general trunk, is at first a little incurvated, appearing as if either it were the only branch of that trunk, or a branch of the trunk of the external carotid. Sometimes the curvature is turned a little outward, and then more or less inward, passing behind the neighbouring external carotid.

It is situated a little more backward than the carotis externa, and generally runs up without any ramification, as high as the lower orifice of the great canal of the apophysis petrosa of the os temporis. It enters this orifice directly from below upward, and afterward makes an angle according to the direction of the canal, the rest of which it passes horizontally, being covered by a production of the dura mater.

At the end of this canal it is again incurvated from below upward, and enters the cranium through a notch of the sphenoidal bone. Then it bends from behind, forward, and makes a third angle on the side of the sella sphenoidalis; and again a fourth, under the clinoid apophysis of that sella. While it lies at the side of the sella turcica, it sends small branches to the parts about the cavernous sinus.

As it leaves the bony canal to enter the cranium, it sends off a small branch through the sphenoidal fissure to the orbit and eye; and soon afterward a considerable branch, called *ophthalmica*, through the foramen opticum, to supply the contents of the orbit. The first branches sent off from the ocular artery are very small; they go to the dura mater on the optic nerve, and the beginning of the muscles in the bottom of the orbit. Then the lacrymal and ciliary arteries are sent off: afterwards the artery covered with the levator muscles of the eye and upper eye-lid turns inwards between these muscles and the optic nerve almost at a right angle; but about the part where it makes this turn, it sends off anterior ciliary branches; afterwards two go off to the levator of the eye and upper eye-lid; then the posterior ethmoidal and the arteria centralis retinae are sent off. While it passes over the nerve, it gives off the musculares superior, inferior, and other ciliary nerves. It lies now at the inner side of the orbit, under the superior oblique and adductor muscles. These muscles, the periosteum, and inner part of the orbit, and

and optic nerve, receive branches from it; then it produces the æthmoidal anterior; its trunk next descends under the cartilaginous pulley of the superior oblique: here it frequently gives a branch to the lacrymal sac; the arteries of the eye-lids also grow from it; at last it divides into four branches, which are the superciliary, the nasal, the superficial, and deep frontals; which last go through the foramen supra orbitarium to be distributed to the forehead. At the inner angle of the eye, it communicates with the angular artery; and within the orbit it sends one or two small branches to the nose. This artery was by the ancients mistaken for a vein. Ingrassius was the first who considered it in its proper light; but Haller was the first who described it with accuracy. For a more minute description, see Zinn and Sabatier.

Afterwards the internal carotid runs under the basis of the brain to the side of the infundibulum, where it is at a small distance from the internal carotid of the other side, and there it commonly divides into two principal branches, one anterior and one posterior.

The anterior branch runs forward under the brain, first separating from that on the other side, then coming nearer again, it unites with it by an anastomosis or communication in the interstice between the olfactory nerves. Afterwards, having sent off small arteries, which accompany these nerves, it leaves its fellow, and divides into two, but, according to Winslow, two or three branches. The first of these is the smallest of the two, but it is a very constant one; it runs forwards at the inner side of the anterior lobe, which it supplies in its passage. The second, after it has got beyond the corpus callosum, to which it sends branches, is reflected back over that substance upon the inner side of the hemisphere, and may be traced back as far as the posterior lobe: in all this course it sends off innumerable branches, which are at first spread out upon

the surface, and afterwards sink into the substance of the brain, communicating freely with the ramifications of the posterior trunk.

The posterior branch communicates first of all with the vertebral artery of the same side, and after running between the anterior and lateral lobes of the brain, divides into several rami, which run between its superficial circumvolutions; and are ramified in many different directions on and between these circumvolutions, all the way to the bottom of the sulci.

All these ramifications are covered by the pia mater, in the duplicature of which they are distributed, and form capillary reticular textures in great numbers; and afterwards they are lost in the inner substance of the brain. The anterior and middle branches produce the same kind of ramifications, and the anterior, in particular, supplies the corpus callosum.

*Arteria subclavia.* The subclavian arteries are named from their situation near the clavicles, in the transverse direction of which they run. They are two in number, one right, the other left; and they arise from the arch of the aorta, on each side of the left carotid, which commonly lies in the middle between them; but when both carotids go out separately, they both lie between the subclaviæ. These arteries terminate, or rather change their name, above the middle of the two first ribs, between the anterior insertions of the musculi scaleni.

The right subclavian is larger at the beginning than the left, when it produces the right carotid; its origin is likewise more anterior and higher, because of the obliquity of the arch of the aorta; for which reason also the left is shorter than the right, and runs more obliquely. Both of them are distributed much in the same manner; and therefore the description of one may likewise be applied to the other.

The right subclavian, the longest of the two, gives off,

off, first of all, small arteries to the mediastinum, thymus, pericardium, aspera arteria, &c. which are named *mediastinæ*, *thymicæ*, *pericardiæ*, and *tracheales*. These small arteries sometimes go out from the subclavian itself, either separately or by small common trunks; sometimes they are branches of the mammaria interna, especially the mediastina.

Afterward this right subclavian, at about a finger's breadth from its origin, commonly produces the common carotid of the same side; and at a small finger's breadth from the carotid, it gives off commonly three considerable branches, viz. the mammaria interna, cervicalis, and vertebralis, and sometimes an intercostal artery, which goes to the first ribs called *intercostalis superior*.

*Arteria thymica.* The arteria thymica communicates with the mammaria interna, and sometimes arises from the anterior middle part of the common trunk of the subclavian and carotid. The thymus receives likewise some rami from the mammaria interna and intercostalis superior. The same observation may be applied to the mediastina and pericardia.

*Arteria pericardia.* The pericardia arises much in the same manner with the thymica, and runs down upon the pericardium all the way to the diaphragm, to which it sends some small ramifications.

*Arteria mediastina.* The mediastina arises sometimes immediately after the thymica, and is distributed principally to the mediastinum.

*Arteria trachealis.* The trachealis, which may likewise be named *gutturalis inferior*, runs up from the subclavia, in a winding course, along the aspera arteria, to the glandulæ thyroidææ and larynx, detaching small arteries to both sides, one of which runs to the upper part of the scapula.

*Arteria mammaria interna.* The internal mammary artery comes from the anterior and lower side of the

subclavia, near the middle of the clavícula, and runs down behind the cartilages of the true ribs near the edge of the sternum.

In its passage it sends rami to the thymus, mediastinum, pericardium, pleura, and intercostal muscles. It likewise detaches other branches, through these muscles and between the cartilages of the ribs, to the pectoralis major, and other neighbouring muscular portions, to the mammae, membrana adiposa, and skin.

Several of these rami communicate, by anastomoses, with the mammaria externa, and other arteries of the thorax, especially in the substance of the pectoralis major, and likewise with the intercostals. Afterwards it goes out of the thorax on one side of the appendix ensiformis, and is lost in the musculus abdominis rectus, a little below its upper part; communicating, at this place, by several small ramifications with the arteria epigastrica; and, in its course, it gives branches to the peritonæum, and to the anterior part of the oblique and transverse muscles of the abdomen.

*Arteria cervicalis.* The cervical artery arises from the upper side of the subclavian, and is presently afterwards divided into two, which come out sometimes separately, sometimes by a small common trunk. The largest of these two arteries is anterior, the other posterior.

The anterior cervicalis, running behind the carotid of the same side, is distributed to the musculus coraco-hyoidæus, mastoidæus, cutaneus, sterno-hyoidæus, and sterno-thyroidæus, to the jugular glands, the aspera arteria, the muscles of the pharynx, bronchia, œsophagus, and to the anterior muscles which move the neck and head. This artery has been observed to send out the intercostalis superior.

The posterior cervicalis arises sometimes a little after the vertebralis, and sometimes from that artery. It passes under the transverse apophysēs of the last verte-

bra

bra of the neck; and sometimes through a particular hole in that apophysis; and from thence runs up backward in a winding course, on the vertebral muscles of the neck, and then returns in the same manner.

It communicates with a descending branch of the occipital artery, and with another of the vertebral artery above the second vertebra. It is distributed to the musculi scaleni, angularis scapulæ, and trapezius, and to the jugular glands and integuments.

*Arteria vertebralis.* The vertebral artery goes out from the posterior and upper side of the subclavian, almost opposite to the mammaria interna and cervicalis. It runs up through all the holes in the transverse apophysis of the vertebræ of the neck, and in its passage sends off little twigs through the lateral notches of these vertebræ, to the medulla spinalis and its coverings. It also gives arteries to the vertebral muscles, and to other muscles near them.

As it passes through the transverse hole of the second vertebra, it is generally incurvated, to accommodate itself to the particular obliquity of this foramen. And between this hole and that in the first vertebra, it takes another larger turn in a contrary direction to the former. Having passed the transverse hole of the first vertebra, it is considerably incurvated a third time, from before backwards, as it goes through the superior and posterior notch in this vertebra.

At this third curvature, it sends off a small branch, which is ramified on the outer and posterior parts of the occiput, and communicates with the cervical and occipital arteries. Having afterwards reached the great foramen of the os occipitis, it enters the cranium, and pierces the dura mater; and on these accounts it may be named *arteria occipitalis posterior*, to distinguish it from the other which is lateral.

As soon as it enters the cranium, it sends several

small ramifications to the back-part of the medulla oblongata, and to the corpora olivaria and pyramidalia, which are likewise spread on the back-sides of the fourth ventricle of the brain, and form the plexus choroides of the cerebellum.

Afterwards it advances on the apophysis basilaris of the os occipitis, inclining by small degrees toward the vertebral artery of the other side, all the way to the extremity of that apophysis, where they both join in one common trunk, which may be named *arteria basilaris*.

*Arteria basilaris.* The arteria basilaris runs forward under the great transverse protuberance of the medulla oblongata, to which it gives ramifications, as well as to the neighbouring parts of the medulla. Commonly this artery divides again near the extremity of the apophysis basilaris into four lateral branches, which communicate with the posterior branches of the two internal carotids, and are lost in the posterior lobe of the brain. The first and smallest of each side forms the artery superior cerebelli, which goes to the upper part of this viscus, and to the nates, testes, &c. and at last is lost in the inner substance of the cerebellum. The other branch on each side is much more considerable : this forms the arteria posterior, or profunda cerebri, which supplies the posterior lobe of the brain, and parts lying near the third ventricle. The arteria posterior cerebri, on each side, likewise communicate with the trunk of the internal carotid, by a branch something similar to that between the anterior branches of the carotids: these assist in forming the circle of Willis.

*Arteriae spinale. The spinal arteries are two in number, one anterior, and one posterior ; both produced by both vertebrales ; each of which, as soon as it enters the cranium, sends out a small branch, by the union of which the posterior spinalis is formed. Afterwards*

wards the vertebrales advancing on the apophysis basilaris, or production of the occipital bone, detach backward two other small branches, which likewise meet, and by their union form the spinalis anterior. These spinal arteries run down on the fore and back sides of the medulla spinalis, and, by small transverse ramifications, communicate with those which the intercostal and lumbar arteries send to the same part.

*Arteria auditoria interna.* The internal auditory artery goes off from each side of the arteria basilaris to the organ of hearing, accompanying the auditory nerve, having first furnished several small twigs to the membra arachnoides.

*Arteria meningæa posterior.* The posterior meningæa arises from the same trunk with the auditoria interna, and goes to the back-part of the dura mater, on the occipital and temporal bones, and likewise supplies the neighbouring lobes of the brain.

*Arteria intercostalis superior.* When the superior intercostal artery does not go out from the trunk of the aorta descendens, it commonly arises from the lower side of the subclavian, and runs down on the inside of the two, three, or four, uppermost true ribs, near their heads, and sends off under each rib a branch which runs along the lower edge, and supplies the intercostal muscles and neighbouring parts of the pleura.

These branches or particular intercostal arteries communicate with each other at different distances by small rami, which run upward and downward from one to the other, on the intercostal muscles.

They likewise give branches to the musculi sternohyoidæi, subclavius, vertebrales, and bodies of the vertebrae; and also to the pectoralis major and minor, piercing the intercostal notch; and lastly, they send branches through the muscles of the first four vertebrae to the medulla spinalis and its coverings.

Sometimes the superior common intercostal artery comes

comes from the cervicalis, and not immediately from the subclavia. Sometimes it arises from the aorta descendens, either by small separate arteries, or by a common trunk, which divides as it runs obliquely up upon the ribs. Lastly, it sometimes arises from the nearest bronchiales, or from several bronchiales together.

*Ductus arteriosus in ligamentum versus.* The ductus arteriosus, which is found only in the foetus and in very young children, arises from the aorta descendens, immediately below the left subclavian artery. In adults, this duct is shrunk up and closed, and appears only like a short ligament, adhering by one end to the aorta, and by the other to the pulmonary artery; so that in reality it deserves no other name than that of *ligamentum arteriosum*.

*Arteria bronchialis.* The bronchial arteries are two or three in number, one on the right side, and one or two on the left. The right comes commonly from the superior intercostal, the left from the aorta, and sometimes from the arteria œsophagæa. Sometimes they arise separately from each side, to go to each lung, and sometimes by a small common trunk, which afterwards separates toward the right and left hand, at the bifurcation of the aspera arteria, and accompany the ramifications of the bronchia.

The bronchial artery on the left side often comes from the aorta, while the other arises from the superior intercostal on the same side; which variety is owing to the situation of the aorta. Sometimes there is another bronchial artery which goes out from the aorta posteriorly, near the superior intercostal, above the bronchialis anterior.

Sometimes there are free communications observed between the branches of the bronchial artery and those of the pulmonary artery: these have been mistaken

ken for direct communications between the bronchial artery and pulmonary vein, *vena azygos*, &c.

The bronchialis gives a small branch to the neighbouring auricle of the heart, which communicates with the arteria coronaria.

*Arteriae œsophagææ.* The œsophagææ are generally two or three in number, sometimes but one. They arise anteriorly from the aorta descendens, and are distributed to the œsophagus, &c. Sometimes the uppermost œsophagæa produces a bronchial artery.

*Arteriae intercostales inferiores.* The inferior intercostals are commonly seven or eight on each side, and sometimes ten, when the superior intercostals arise likewise from the aorta descendens; in which case these run obliquely upward, as has been already said.

They arise along the backside of the descending aorta in pairs, all the way to the diaphragm, and run transversely towards each side, on the bodies of the vertebræ. Those on the right side pass behind the *vena azygos*; and afterwards they all run to the intercostal muscles, along the lower edge of the ribs, all the way to the sternum, or near it.

They send branches to the pleura, to the vertebral muscles, to those muscles which lie on the outsides of the ribs, and to the upper portions of the muscles of the abdomen; and they communicate with the arteriæ epigastricæ and lumbares.

Sometimes, instead of going out from the aorta in pairs, they arise by small common trunks, which afterwards divide, and send an artery to each neighbouring rib.

Before they take their course along the ribs, each of them detaches one branch between the transverse apophyses on both sides, to the vertebral muscles, and another which enters the great canal of the spina dorsi. Each of these latter branches divides at least into two small arteries; one of which runs transversely on the anterior

anterior side of the canal, the other on the posterior side. Both of them communicate with the like arteries from the other side of the spine, in such a manner as to form a kind of arterial rings, which likewise communicate with each other by other small ramifications. The same is to be observed in the arteriæ lumbares.

Afterwards each intercostal artery having reached the middle of the rib, or a little more, divides into two principal branches, one internal, the other external. Soon after this division, the arteries that run upon the false ribs separate a little from them, being gradually bent downward one after another, and are spread upon the abdominal muscles. They are likewise distributed to other neighbouring muscles, and particularly to those of the diaphragm, almost in the same manner with the arteriæ phrænicæ; they also communicate with the lumbares, and sometimes with branches of the hypogastricæ.

*Arteriæ axillares.* The subclavian artery having left the thorax immediately above the first rib, in the interstice left between the portions of the scalenus, there receives the name of *axillaris*, because it passes under the axilla.

In this course it gives off, from its inside, a small branch to the inside of the first rib; and afterwards four several principal branches, viz. the thoracica superior, mammaria externa, thoracica humeralis, and *axillaris scapulares*.

*Arteria thoracica superior.* The superior thoracica gives branches to the two pectoral muscles, to the *musculus subclavius*, *serratus major*, and *intercostales externi*. It likewise communicates with the *thoracica longa* and *intercostales*. *Thoracica longa* of Sabatier, or *mammaria externa* of others, sends branches to the *axillary glands*, to the two pectoral muscles, to the *serratus major*, *intercostales externi*, to the *mamma*, and

at last to the integuments. Arteria thoracica humeralis gives first a branch to the serratus major, another runs up to the sterno-mastoid muscle; one supplies the substance of the clavicle and the parts over it; one branch, in particular, runs between the clavicle and small pectoral muscle, to which it sends branches, and communicates with the internal mammari; but the principal part of the thoracica humeralis descends between the great pectoral and deltoid muscles, and is distributed about the parts surrounding the articulation at the top of the humerus. Another artery, called *thoracica axillaris*, sometimes goes off from the former, to be disposed upon the glands, &c. in the axilla.

*Scapularis inferior.* The inferior thoracic artery runs along the inferior costa of the scapula, to the musculus subscapularis, teres major and minor, infra-spinatus, latissimus dorsi, serratus major, and the neighbouring intercostal muscles, communicating with the arteriae scapulares.

*Arteria scapularis externa.* The external scapular artery passes through the notch in the superior costa of the scapula, to the musculus supra-spinatus and infra-spinatus, teres major and minor, and to the articulation of the scapula with the os humeri.

*Arteria scapularis interna.* The internal scapularis arises from the axillary artery near the axilla, and runs backward, to be distributed to the subscapularis, giving branches to the serratus major, to the axillary glands, and to the teres major, upon which it is ramified in different manners. It likewise sends rami to the infra-spinatus and upper portion of the triceps.

*Arteria articularis.* The articular artery arises from the lower and fore part of the axillaris, and runs backward between the head of the os humeri and teres major, surrounding the articulation till it reaches the posterior part of the deltoides, to which it is distributed.

During

During this course, it gives several branches to the superior portions of the anconæi, to the capsular ligament of the joint of the shoulder, and to the os humeri itself through several holes immediately below the great tuberosity of the head of that bone. It likewise communicates with the scapular artery.

Opposite to the origin of this articular artery, the axillaris sends off another small branch, which runs in a contrary direction between the head of the os humeri and the common upper part of the biceps and coraco-brachialis; and having given branches to the vagina and channel of the biceps, and to the periosteum, afterwards joins the principal humeralis.

*Arteria brachialis.* The axillary artery having given off these branches, passes immediately behind the tendon of the pectoralis major, where it changes its former name for that of *arteria brachialis*. It runs down on the inside of the arm over the musculus coraco-brachialis and anconæus internus, and along the inner edge of the biceps behind the vena basilica, giving small branches on both sides to the neighbouring muscles, to the periosteum, and to the bone.

Between the axilla and middle of the arm, it is covered only by the skin and fat; but afterwards it is hid under the biceps, and runs obliquely forward as it descends; being at some distance from the internal condyle, but it does not reach the middle of the fold of the arm.

Between the axilla and this place, it sends off many branches to the infra-spinatus, teres major and minor, subscapularis, latissimus dorsi, serratus major, and other neighbouring muscles, to the common integuments, and even to the nerves. Below the fold of the arm, it divides into two principal branches, one called *arteria cubitalis*, the other *radialis*.

From its upper and inner part, it sends off a particular branch, which runs obliquely downward and backward

ward over the triceps, and then turns forward again near the external condyle, where it communicates with a branch of the arteria radialis.

Immediately below the insertion of the teres major, it gives off another branch, which runs from within outwards, and from behind forward, round the os humeri; and descends obliquely forward, between the musculus brachialis and triceps, to both which it is distributed in its passage. Having afterwards reached the external condyle, it unites with the branch last mentioned, and likewise communicates with a branch of the arteries of the fore-arm, so that there is here a triple anastomoses.

About the breadth of a finger below this second branch, the brachial artery sends off a third, which runs down toward the internal condyle, and communicates with other branches of the arteries of the fore-arm.

About the middle of the arm, or a little lower, much about the place where the brachial artery begins to be covered by the biceps, it sends off a branch, which is distributed to the periosteum, and penetrates the bone between the brachialis and inner side of the triceps.

About an inch lower, it gives off another branch, which having furnished ramifications to the inner side of the triceps, runs over the inner condyle, and likewise communicates with branches of the arteries of the fore-arm.

Having got below the middle of the arm, the brachial artery detaches another branch, which runs behind the inner condyle in company with the ulnar nerve; and having passed over the muscles inserted in this condyle, it communicates with that branch of the cubital artery which encompasses the fold of the arm.

A little lower it sometimes sends out another branch, which passes on the foreside of the inner condyle, and then communicates with a branch which runs up from the

the cubital artery. These three communicating branches are termed *collateral arteries*.

The common trunk of the brachial artery having reached the fold of the arm, runs, together with a vein and the radial nerve, immediately under the aponeurosis of the biceps, and passes under the vena mediana, detaching branches on each side to the neighbouring muscles.

About a large finger's breadth beyond the fold of the arm, this artery divides into the two principal branches called *cubitalis* and *radialis*.

From this bifurcation, the brachial artery sends branches on each side, to the supinator longus, pronator teres, fat, and skin. It sometimes, though very rarely, happens, that this artery is divided from its origin into two large branches, which run down on the arm, and afterwards on the fore-arm, where they have the names of *cubitalis* and *radialis*.

*Arteria cubitalis.* The cubital, or ulnar artery, which lies at the inner side, and is the largest of the two, sinks in between the brachialis internus and pronator teres; then between the sublimus and profundus, and afterwards runs down between the sublimus and flexor carpi ulnaris, all the way to the carpus and great transverse ligament. In this course it winds and turns several ways, and sends out several branches.

The first is a small artery, which runs inward to the inner condyle, and then turns upward like a kind of recurrent, to communicate by several branches with the collateral arteries of the arm already mentioned, and particularly with the third. A little lower down, another small branch goes off; which having run upward a short way, and almost surrounded the articulation, communicates with the second collateral artery of the arm, between the olecranon and inner condyle.

Afterwards, the cubital artery having, in its course between the heads of the ulna and radius, reached the inter-

interosseous ligament, sends off two principal branches, one internal, the other external; called the *interosseous arteries* of the fore-arm.

The external artery pierces the ligament about three fingers breadth below the articulation; and presently afterwards gives off a recurrent branch, which runs up toward the external condyle of the os humeri, under the extensor carpi ulnaris and anconæus, to which it is distributed, as also to the supinator brevis; and it communicates with the collateral arteries of the arm on the same side.

Afterward this external interosseous artery runs down on the outside of the ligament, and is distributed to the extensor carpi ulnaris, extensor digitorum communis, and to the extensores pollicis indicis and minimi digiti; communicating with some branches of the internal interosseous artery.

Having reached the lower extremity of the ulna, it unites with a branch of the internal interosseous artery, which at this place runs from within outward, and is distributed together with it on the convex side of the carpus and back of the hand, communicating with the arteria radialis, and with a branch of the cubitalis; which shall be mentioned hereafter.

By these communications, this artery forms a sort of irregular arch, from whence branches are detached to the external interosseous muscles, and to the external lateral parts of the fingers.

The internal interosseous artery runs down very close to the ligament, till it reaches below the pronator teres; between which and the pronator quadratus it perforates the ligament, and goes to the convex side of the carpus and back of the hand, where it communicates with the external interosseous artery, with the radialis and internal branches of the cubitalis.

From the origin of the two interosseæ, the cubital artery descends, sending branches to the neighbouring parts. Below the internal interossea, it sometimes

sends off a branch which runs down between the flexor pollicis, flexor carpi radialis, and perforatus ; to which it is distributed all the way to the carpus, where it runs under the internal annular ligament, and communicates on the hand with branches of the arteria radialis.

Afterward the cubital artery passes over the internal transverse ligament of the carpus, by the side of the os pisiforme ; and having furnished the skin, palmaris brevis, and metacarpus, it slips under the aponeurosis palmaris, giving off one branch to the abductor minimi digiti, and another which runs towards the thumb between the tendons of the flexors of the fingers and the bases of the metacarpal bones.

It likewise sends off a branch, which, running between the third and fourth bones of the metacarpus, reaches to the back of the hand, where it communicates with the external interosseous artery. Afterwards, having supplied the interosseous muscles, it communicates with the radialis ; and they both form an arterial arch in the hollow of the hand, in the following manner.

The cubitalis having got about two fingers breadth beyond the internal annular ligament of the carpus, forms an arch ; the convex side of which is turned to the fingers, and commonly sends off three or four branches. The first goes to the inner and back part of the little finger ; and is sometimes a continuation or production of that branch which goes to the muscles on the foreside of the little finger.

The other three branches run in the interstices of the four metacarpal bones ; near the heads of which each of them is divided into two branches, which pass along the two internal lateral parts of each finger, from the foreside of the little finger to the posterior side of the index inclusively ; and at the ends of the fingers these digital arteries communicate and unite with each other.

Some-

Sometimes the arch of the cubital artery terminates by a particular branch in the middle finger; and in that case it communicates with the radial artery, which makes up what the other wants.

This arch sends likewise from its concave side, towards the second phalanx of the thumb, a branch for the lateral internal part thereof; and then ends near the head of the first metacarpal bone, by a communication with the radialis, having first given a branch to the foreside of the index, and another to the side of the thumb next the former. These communicate at the ends of the fingers with the neighbouring branches as in the other fingers.

This arch sends likewise small twigs to the interosseous muscles, to the lumbricales, palmaris, and to other neighbouring parts; and, lastly, to the integuments.

*Arteria radialis.* The radial artery begins by detaching a small recurrent branch, which runs upwards toward the fold of the arm, and turns backward round the external condyle, communicating with the neighbouring branches from the trunk of the brachial artery, especially with the first collateral branch on that side.

It runs down along the inside of the radius, between the supinator longus, pronator teres, and the integuments, giving branches to these muscles, and likewise to the perforatus, perforans, and supinatof brevis. From thence it runs in a winding course toward the extremity of the radius, supplying the flexors of the thumb and pronator quadratus.

Having reached the extremity of the radius, it runs nearer the skin, especially toward the anterior edge of the bone, being the artery which we there feel when we examine the pulse.

At the end of the radius, it gives off a branch to the abductor pollicis; and after having communicated with the arch of the cubital artery in the palm of the hand,

and sent off some cutaneous branches at that place, it detaches one along the whole internal lateral part of the thumb.

Afterwards it runs between the first phalanx and tendons of the thumb, to the interstice between the basis of this first phalanx and of the first metacarpal bone, where it turns toward the hollow of the hand.

At this turning, it sends off a branch to the external lateral part of the thumb, which, having reached the end thereof, communicates by a small arch with the branch which goes to the internal lateral part.

It likewise sends branches outward, which run more or less transversely between the first two bones of the metacarpus and the two tendons of the extensores carpi radiales; and it communicates with an opposite branch of the cubitalis; together with which it furnishes the external interosseous muscles and integuments of the back of the hand and convex side of the carpus.

Lastly, the radial artery terminates, in its passage over the abductor muscle of the index, near the basis of the first metacarpal bone, and as it runs under the tendons of the flexor muscles of the fingers, where it is joined to the arch of the cubitalis.

It sends off another branch, which runs along the forepart of the first bone of the metacarpus to the convex side of the index, where it is lost in the integuments.

It gives likewise a branch to the internal lateral part of the index; which, at the end of that finger, joins an opposite branch which comes from the arch of the cubitalis. It also sends off a small branch across the internal interosseous muscles, where it forms a kind of small irregular arch, which communicates with the great arch by several small arterial rami.

When the arch of the cubitalis ends at the middle finger, the radialis runs along the inner or concave part of the first metacarpal bone; at the head of which it terminates by two branches.

One of these branches runs along the inner and anterior lateral part of the index; the other passes between the flexor tendons of this finger and the metacarpal bone; and having communicated with the cubital branch of the middle finger, it advances on the posterior lateral part of the index all the way to the end of that finger, where it unites again with the first branch.

*Arteria diaphragmatica.* The left diaphragmatic artery goes out commonly from the aorta descendens as it passes between the crura of the small muscle of the diaphragm. The right diaphragmatic comes sometimes from the nearest lumbar artery, but frequently from the cæliaca. Sometimes both these arteries arise by a small common trunk immediately from the aorta. They likewise have the name of *arteria phrenica*.

They appear almost always in several ramifications on the concave or lower side of the diaphragm, and seldom on the upper or convex side. They give small branches to the glandulæ renales, and fat upon the kidneys, to the liver, and to the superior orifice of the stomach.

Besides these capital diaphragmatic arteries, there are others of a subordinate class, which come from the intercostales, mammariae internæ, mediastinæ, pericardia, and cæliaca, all of which communicate freely with the large diaphragmatics, as those on the right and left sides of the diaphragm do with each other.

*Arteria cæliaca.* The cæliac artery rises anteriorly and a little to the left side, from the aorta descendens, immediately after its passage through the small muscle of the diaphragm, nearly opposite to the cartilage between the last vertebra of the back and first of the loins. The trunk of this artery is very short; and near its origin it sends frequently off the right diaphragmatica.

Immediately after this, the cæliaca divides into three branches; one runs upwards, termed *arteria ventriculi coronaria*; one toward the right hand, named *arteria hepato-*

*hepatica*; the other to the left, called *splenica*, which is larger than the former.

This artery is divided into these three branches at the same place, very near its origin; the trunk going out from the aorta almost in a straight line, and the branches from the trunk almost at right angles, like radii from an axis; whence this trunk has been called *axis arteriæ cœliacæ*. Frequently, however, the *ventriculi coronaria* comes off first, then the *cœlica* divides into two parts.

*Arteria ventriculi coronaria*, or *gastrica*, or *gastro superior*. The coronary artery of the stomach goes first to the left side of that organ, a little beyond the superior orifice; round which orifice it throws branches, and also to every part of the stomach near it; and these branches communicate with those which run along the bottom of the stomach to the pylorus.

Afterwards it runs on the right side of the superior orifice, along the small curvature of the stomach, almost to the pylorus, where it communicates with the *arteria pylorica*; and turning towards the small lobe of the liver, it gives off some branches to it.

Then it advances, under the *ductus venosus*, to the left lobe of the liver, in which it loses itself near the beginning of the just-mentioned duct, having first given off some small branches to the neighbouring parts of the diaphragm and omentum.

*Arteria hepatica*. As soon as the hepatic artery leaves the *cœliaca*, it runs to the upper and inner part of the pylorus, in company with the *vena portæ*, sending off two branches; a small one called *arteria pylorica*, and a large one named *gastro dextra*, or *gastro major*.

The *pylorica* is ramified on the pylorus, from whence it has its name; and having distributed branches to the neighbouring parts of the stomach, which communicate with those of the right *gastro*, it terminates on the pylorus, by an anastomosis, with the coronary artery of the stomach.

The

The right gastric artery having passed behind and beyond the pylorus, sends out a considerable branch, named *arteria duodenalis*, or *intestinalis*; which sometimes comes from the trunk of the hepatica, as we shall see hereafter. Afterwards this gastric artery runs along the right side of the great curvature of the stomach; to the neighbouring parts of which, on both sides, it distributes branches.

These branches communicate with those of the arteria pylorica, and of the coronaria ventriculi, and with the right gastro-epiploicæ, which furnish the nearest parts of the omentum, and communicate with the mesenterica superior. After this, the right gastric artery ends in the left, which is a branch of the splenica.

The duodenal or intestinal artery runs along the duodenum on the side next the pancreas; to both which it furnishes branches, and also to the neighbouring part of the stomach. Sometimes this artery goes out from the mesenterica superior, and sometimes it is double.

The hepatic artery having sent out the pylorica and right gastrica, advances behind the ductus hepaticus, toward the vesicula fellis, to which it gives two principal branches, called *arteriae cysticæ*; and another named *bilaria*, which is lost in the great lobe of the liver.

Afterwards this artery enters the fissure of the liver, and joins the vena portæ, with which it runs within a membranous vagina, called *capsula glissoni*; and accompanies it through the whole substance of the liver by numerous ramifications, which may be termed *arteriae hepaticæ propriae*.

Before it enters the liver, it gives small branches to the external membrane of this viscus, and to the capsula glissoni. The gastric and proper hepatic arteries come sometimes from the mesenterica superior, when the ordinary ramifications are wanting.

*Arteria splenica.* Immediately after the origin of the

splenic artery from the cæliaca, it runs toward the left hand, under the stomach and pancreas, to the spleen. It adheres closely to the posterior part of the lower side of the pancreas, to which it gives several branches, named *arteriæ pancreaticæ*.

Near the extremity of the pancreas, under the left portion of the stomach, the splenic artery gives off a principal branch, called *gastrica sinistra* or *minor*, which runs from left to right along the left portion of the great curvature of the stomach, giving branches to both sides of this portion, which communicate with those of the *coronaria ventriculi*.

This gastric artery sends likewise another branch at least to the extremity of the pancreas, which communicates with the other pancreatic arteries. It also supplies the omentum with branches, termed *gastro-epiploicæ sinistræ*; and then it communicates with the right *gastrica*; and from this union the *gastro epiploicæ medæ* are produced.

From this detail we learn, that the *arteria coronaria ventriculi pylorica, intestinalis, both gastricae, gastro-epiploicæ*, and consequently the *hepatica, splenica, and mesenterica*, communicate all together.

Afterwards the splenic artery advances towards the spleen, in a course more or less contorted; but before it arrives at that viscus, it gives two or three branches to the large extremity of the stomach, commonly called *vasa brevia*; and one to the omentum, named *epiploica*.

At the spleen, this artery divides into four or five branches, which enter that viscus, after having given some small twigs to the neighbouring parts of the stomach and omentum.

*Arteria mesenterica superior.* The superior mesenteric artery arises anteriorly from the lower portion of the descending aorta, a very little way beyond the cæliaca, going out a little towards the right hand, but bending immediately afterwards to the left.

Near

Near its origin, it gives off a small branch, which dividing into two, goes to the lower side of the head of the pancreas, and neighbouring part of the duodenum, communicating with the intestinalis by small arches, and areolæ or mashes.

Afterwards it passes over the duodenum, between this intestine and the mesenteric vein, between the two laminæ of the mesentery; and then bending in an oblique direction from left to right, and from above downward, by very small degrees, it advances toward the extremity of the ilium. By this incurvation, it forms a kind of long arch, from the convex side of which a great many branches go out.

These branches are sixteen or eighteen in number, or thereabouts; and almost all of them are bestowed on the small intestines, from the lower third part of the duodenum to the cæcum and colon. The first branches are very short; and from thence they increase gradually in length all the way to the middle of the arch; the rest diminishing again by small degrees.

As they approach the intestines, all these branches communicate, first by reciprocal arches, then by areolæ and mashes of all kinds of figures; from which is detached an infinite number of small ramifications, which surround the intestinal canal, like an annular piece of net-work.

These arches and mashes increase in number proportionably to the length of the branches; and their size diminishes gradually as they approach the intestines.

The first branches from the convex side of the mesenteric arch, which are very short, supply the pancreas and mesocolon, and communicate with the duodenal artery. The last branches go to the appendicula vermiciformis, and send a portion of an arch to the beginning of the colon.

The considerable branches from the concave side of the mesenteric arch are seldom above two or three in number; but before they arise, a small ramus goes out

to the duodenum, and gives some very small arteries to the pancreas.

The first considerable branch from the concave side of the arch goes into the mesocolon towards the right portion of the colon, being first divided into two rami; the first of which runs along the whole superior part of the colon, where it forms the famous communication with the mesenterica inferior, and might be named *arteria colica superior*. The other ramus of this branch runs down on the right portion of the colon.

The second principal branch having run for some space through the mesentery, divides into three rami; the first of which goes to the lower part of the right portion of the colon, where it communicates with the second ramus of the first branch; the second goes to the beginning of the colon, where it communicates with the first and to the intestinum cæcum.

The third ramus of this second branch having communicated with the second, gives small twigs to the cæcum, appendicula vermicularis, and extremity of the ileum. Afterwards it communicates with the extremity of the arch, or curve trunk of the superior mesenteric.

All these communications are by arches and meshes, as in those branches that come from the convex side of the arch; and it is to be observed in general, that all the branches of the mesenterica superior are disposed according to the folds of the mesentery and circumvolutions of the intestines; giving off branches, through their whole course, to the laminæ of the mesentery, its cellular substance, and to the mesenteric glands.

*Arteria mesenterica inferior.* The lower mesenteric artery goes out anteriorly from the aorta descendens inferior, about a finger's breadth or more above the bifurcation, and below the spermatic arteries; and having run about the length of an inch, or something more, it is divided into three or four branches, which gradually separate from each other.

The first or superior branch, about an inch from its origin,

origin, divides into two rami ; the first of which runs along the left portion of the colon, and forms the communication of the two mesenteric arteries already mentioned. It may be named *arteria colica sinistra*. The second ramus having communicated with the first, runs down upon the same portion of the colon.

The middle branch having run the same length with the first, divides into two rami ; one of which passes upward on the extremity of the colon, communicating by arches with the second ramus of the superior branch ; the other runs down on the extremity of the same intestine.

When there is another middle branch, it goes to the first part of the double curvature of the colon by a like distribution and communication from above downward.

The lower branch goes to the second portion of the colon, or to both, when the second middle branch is wanting, and sends up a ramus, which communicates with the foregoing.

It sends another considerable branch downward, called *arteria haemorrhoidalis interna*, which runs down behind the *intestinum rectum*, to which it is distributed by several ramifications ; and it communicates with the arteriae hypogastricæ.

*Arteriae renales.* The renal arteries, called commonly *emulgents*, are ordinarily two in number, and go out laterally from the inferior descending aorta, immediately under the *mesenterica superior* ; one to the right hand, the other to the left. The right is situated more backward, and is longer than the left, because of the *vena cava*, which lies on the right side between the aorta and the kidney.

They run commonly without division, and almost horizontally to the kidneys, into the depressions of which they enter by several branches, which form arches in the inner substance of these viscera.

From these arches, numerous small rami go out toward

ward the circumference or outer surface of the kidneys. Sometimes there is more than one artery on each side ; sometimes this augmentation is only on one side, and these supernumerary arteries come sometimes immediately from the aorta, and enter at the upper or lower part of the kidneys. It is not uncommon to find two, three, or four, on each side, and some, or all of these, from the iliac arteries.

Ordinarily, the right renal artery passes behind the vena cava and renal vein on the other side ; and the left artery, first behind and then before the vein. Sometimes they send branches to the glandulæ renales, membrana adiposa of the kidneys, and even to the dia-phragm.

*Arteria capsulares.* The arteries of the renal glands, which may be termed *arteria capsulares*, arise from the aorta above the arteria renalis, and give out the arteriæ adiposæ, which go to the fat of the kidneys. Sometimes they come from the trunk of the cæliaca. The right capsular artery comes most commonly from the arteria renalis of the same side, near its origin ; the left from the aorta above the renalis. They send branches to the parts which surround them, and communicate there with branches of other arteries.

*Arteria spermatica.* The spermatic arteries are commonly two in number, sometimes more. They are very small ; and go out anteriorly from the aorta descendens inferior, near each other, about a finger's breadth below the arteriæ renales, more or less, between the two mesentericæ, or between the renales and me-sentericæ inferiores. Sometimes one is higher, or placed more laterally than the other ; and sometimes there are two on each side.

They send off to the common membrane of the kidneys small branches named *arteria adiposa* ; and afterwards they run down upon the psoas muscles, on the foreside of the ureters, behind the peritonæum.

They give several considerable branches to the peritonæum, chiefly to those parts of it which are next the mesentery, and they communicate both with the mesentericæ and adiposæ. They likewise send small arteries to the ureters.

Afterwards they pass, in men, through the tendinous openings of the abdominal muscles in the vagina of the peritonæum, and are distributed to the testicles and epididymis, where they communicate with a branch of the iliaca externa.

In women, they do not go out of the abdomen, but are distributed to the ovaria and uterus, and communicate with branches of the hypogastrica, at the jagged extremities of the tubæ Fallopianæ.

*Arteriæ lumbares.* The lumbar arteries go out posteriorly from the inferior descending aorta, in five or six pairs, much in the same manner with the intercostals.

They may be divided into superior and inferior. The superior send small branches to the neighbouring parts of the diaphragm and intercostal muscles, and supply the place of semi-intercostal arteries. Sometimes those pairs go out by a small common trunk, and not separately.

They are distributed on each side to the psoas muscles, to the quadrati lumborum, and to the oblique and transverse muscles of the abdomen; and by perforating the oblique muscles, they become external hypogastric arteries. They go likewise to the vertebral muscles, and to the bodies of the vertebræ, and enter the spinal canal through the lateral notches, to go to the membranes, &c. forming rings much in the same manner with the intercostals; and they likewise give small twigs to the nerves.

*Arteriæ sacræ.* The arteria sacra media goes out commonly from the back part of the inferior descending aorta, at the bifurcation. Sometimes it arises higher from the lumbares, and sometimes lower from the iliaca.

iliacæ. Sometimes there are two, three, or four, in number. The branches of this artery are ramified on the os sacrum, and on the neighbouring parts of the peritonæum, intestinum rectum, fat, &c. ; and enter the canal of that bone through the anterior holes, being there distributed toward each side. They likewise send small arteries to the large fasciculi of nerves which go out through the holes of the os sacrum, and they penetrate the inner substance of that bone. The os sacrum has also branches spread out upon its surface, and some running through its anterior holes from the hypogastric artery.

*Arteriæ iliacæ.* The inferior descending aorta ends at the last vertebra of the loins, and sometimes higher, in two large lateral branches, one on the right hand, the other on the left, called *arteriæ iliacæ*; each of which is a common trunk to two other arteries of the same name. This bifurcation lies on the anterior and left side of that of the *vena cava*.

The primitive iliac arteries davaricate gradually as they descend, advancing obliquely toward the anterior and lower part of the ossa ilium, without any considerable ramification, for about the breadth of three fingers, except a few very small arteries that go to the os sacrum; some of which enter by the upper holes, and are distributed like the *arteriæ sacræ*, while others emerge again through the posterior holes, and go to the neighbouring muscles, &c. They likewise give small arteries to the peritonæum, to the coats of the veins, and to the fat and ureters, behind which the iliac trunks pass.

The right iliac trunk passes first on the foreside of the origin of the left iliac vein, and runs down on the foreside of the right vein, almost to the place where it goes out of the abdomen, its course being there directed more inwardly. The left trunk goes down likewise before the left vein, but lies a little toward the inside as it leaves the abdomen.

About three fingers breadth from their origin, and opposite to the union of the os sacrum with the posterior part of the os ilium, each iliac trunk is divided into two secondary arteries, one external, the other internal. The external artery has no particular name; the internal is termed *hypogastrica*, which often appears to be no more than a branch of the other, in adults; but in young children, and especially in the *fœtus*, the hypogastric artery looks like the trunk, and the other like a branch.

The external iliac on each side runs down on the iliac muscle to the ligamentum Fallopii, under which it goes out of the abdomen. In this course, it gives off only a few small arteries, to the peritonæum and other parts near it; but as it passes out of the abdomen under the ligament, it detaches two considerable branches, one internal, the other external.

The internal branch is named *arteria epigastrica*, and goes out anteriorly from the external iliaca. From thence it runs obliquely upward on the tendon of the transverse muscle toward the posterior part of the rectus, which it reaches about two or three fingers breadth above the os pubis.

Afterwards the epigastric artery runs up along the posterior or inner side of this muscle, sending ramifications to the tendons of the neighbouring muscles, &c.; and then loses itself by a true anastomosis of several ramifications, with the *mammaria interna*. It likewise communicates with the inferior intercostals, which are spread on the abdomen.

It sometimes gives out two particular branches; one of which, accompanied by a nerve, goes through the foramen ovale of the pelvis to the triceps muscles, &c.; the other runs down to the testicles along with the spermatic artery, and there communicates with it.

The external branch of the outer iliac, or *iliaca anterior* of Sabatier, goes off laterally from the outside of that artery under the ligamentum Fallopii, and from thence

thence to the internal labium of the os ilium, where it divides into two, and is ramified on the oblique and transverse muscles of the abdomen, communicating with the arteria lumbaris.

Besides these two branches, the external iliaca gives off a small ramus internally under the ligament, which runs to the vagina of the spermatic rope; and sometimes another small twig goes from the outside to the os ilium.

The internal iliaca or hypogastrica, having run a little more than a finger's breadth inward and backward, bends by small degrees obliquely forward, and toward the outside; and, afterwards contracting in its dimensions, it ends in the umbilical artery, which ought to be looked upon as a true continuation of the trunk of the hypogastrica.

This arteria umbilicalis ascends on the side of the bladder, and having detached small rami to that viscus and to the neighbouring parts of the peritonæum, &c. it contracts, and in adults is quite closed up, above the middle of the bladder. It likewise gives branches to the uterus in the female, and to the neighbouring parts in both sexes. Afterwards it ascends in form of a ligament to the umbilicus, where it lies contiguous to the umbilical artery on the other side; its name being taken from its use in the foetus.

From the convex side of the curvature of the hypogastric, several principal branches go out very near each other. Sometimes they all arise separately, sometimes by small common trunks, and what is the first branch in some subjects, is only a ramus of another principal branch in others; so much does the number, disposition, origin, and distribution of these branches vary in different subjects. For this reason we think it proper to distinguish them by the following proper names: *iliaca minor, sacrae laterales, glutæa, sciatica, pudica communis, pudica hypogastrica, hemorrhoidalis media, and obturatrix.*

The

The iliaca minor, or ilio-lumbaris, the most posterior of these branches, and which is often no more than a ramus of the glutæa, or of the sacræ laterales, passes behind the musculus psoas, to which it gives twigs, and behind the crural nerve; being afterwards distributed to the iliac muscle, and to the middle part of the inside of the os ilium, penetrating into the substance of the bone, sometimes by one hole, sometimes by more.

Arteriæ sacræ laterales are most commonly two in number, though sometimes only one. They come from the trunk of the hypogastric artery, or from some of its largest branches, and are distributed upon the fore part of the os sacrum; and then, by means of the anterior holes, they go to the nerves, membranes, &c. lying within that bone.

The arteria glutæa, or iliaca posterior, is commonly very considerable, and sometimes the largest of all the hypogastric branches. Near its beginning it sometimes sends out the iliaca minor, and sometimes the sacræ laterales. Afterwards this artery goes out of the pelvis in company with the sciatic nerve, through the upper part of the great sinus of the os innominatum, below the musculus pyriformis, and is distributed in a radiated manner to the glutæus maximus and medius.

In its passage, it gives some branches to the os sacrum, os coccygis, musculus pyriformis, the muscles of the anus, and to the neighbouring parts of the intestinum rectum, forming a particular hæmorrhoidalis interna. It likewise sends twigs to the bladder and parts near it; and detaches a pretty long branch which runs down with the sciatic nerve.

The arteria sciatica gives, first of all, some branches to the musculus pyriformis, the quadrigemini, the os sacrum, &c. and even to the inner side of the os ischium. It likewise detaches a branch which runs under the musculus quadratus, to the articulation of the os femoris.

It passes obliquely over the sciatic nerve; and as they both go through the great posterior sinus of the os ilium, it detaches small arteries, which are distributed to the inner substance of that nerve. Afterwards it runs up in a radiated manner on the outside of the os ilium, and is distributed to the inner substance of that bone, and to the musculi glutæi, especially to the medius and minimus.

The pudica communis, called commonly *pudica interna*, arises sometimes by a trunk common to it and to the glutæa, and gives out two principal branches; the first of which passes through the great sinus of the os ilium in company with the glutæa and sciatica, and then divides into two rami.

The first ramus goes behind the spine of the ischium, between the two ligaments which lie between that bone and the os sacrum; and runs on the inside of the tuberculum ischii, all the way to the origin of the corpus cavernosum penis. There it divides into several arteries, one of which goes to the sphincter ani, under the name of *hemorrhoidalis externa*.

The rest are distributed to the neighbouring integuments, to the bulb of the urethra, and to the corpus cavernosum penis; but the last of these arteries, or rather the extremity of this first ramus, runs from behind forward, over the neck of the os femoris, and communicates with a branch of the arteria cruralis.

The second principal ramus, called commonly *arteria pudica externa*, runs between the bladder and intestinum rectum, and is distributed, in men, to the vesiculæ seminales, neck of the bladder, prostate gland, and neighbouring parts of the rectum.

Afterwards it runs under the os pubis on the side of a considerable vein, which lies directly under the symphysis; and it runs along the penis between this vein and a nerve, being distributed in its passage to the corpus cavernosum, and communicating with the pudica minor, which comes from the cruralis. In the female

a branch of the pudica communis, after having supplied the transverse and sphincter muscles with the integuments, is distributed upon the muscles and substance of the clitoris and outer end of the vagina: A deeper artery belongs to the clitoris, and supplies it somewhat in a similar way as a corresponding artery does the penis.

Hæmorrhoidalis media comes from the pudica interna, or from some of the other large branches. It goes to the lower part of the rectum, which it embraces from behind forwards. It is more frequent in women than in men: in the former, it sends branches likewise to the vagina and bladder; in the latter, it sends branches to the bladder, vesiculæ seminales, and prostate.

Ateriæ vesicales. The bladder is supplied with arteries from the hæmorrhoidalis media, from the uterina, and from the umbilicalis: but besides these, another artery goes commonly off from the trunk of the hypogastrica, and runs to the inferior part of the bladder, where it divides into branches which run to the vesiculæ seminales, vasa deferentia, prostate gland, and beginning of the urethra.

Uterina comes from the under end of the hypogastrica; it sends first branches to the bottom of the bladder and urethra; then it goes to the lower part of the uterus, where it divides into numerous serpentine branches, which are distributed upon the uterus, and which communicate freely with the spermatic arteries. It sends likewise a branch to the vagina, which extends also to the bladder, urethra, and rectum.

Arteria vaginalis. The arteries of the vagina come from the hæmorrhoidalis media, from the vesicales and uterina: sometimes a branch arises likewise from the trunk common to the ischiatica and pudica interna. This goes to the under part of the vagina, and communicates with branches which run upon the external parts of generation.

The arteria obturatrix perforates the obturator muscles, from whence it has its name, and goes out of the pelvis at the upper part of the ligament of the foramen ovale, having first sent a small branch over the symphysis of the os ilium and os pubis, to the inguinal glands and integuments.

As it passes by the muscles, it divides and is distributed to the pectineus and triceps. It likewise sends out another branch, which communicates with that branch of the sciatica that goes to the articulation of the os femoris, and gives small arteries to the holes of the neck of that bone. According to Sabatier, this artery comes sometimes from the epigastric; and Lieutaud has seen it sent off from the external iliac artery.

Afterwards the hypogastric artery ends in the umbilicalis, as has been already said.

*Arteriae crurales.* The iliac artery goes out of the abdomen between the ligamentum Fallopii and tendon of the psoas, at the union of the os ilium and os pubis; and there it takes the name of *arteria cruralis*.

It sends off, first of all, three small branches; one of which, called *pudica externa*, goes over the crural vein to the skin and ligament of the penis, and to the inguinal glands, communicating with the *pudica interna*. The second goes to the *musculus pectineus*; and the third to the upper part of the *sartorius*. All these branches furnish likewise the neighbouring anterior integuments.

Afterwards the crural artery runs down on the head of the os femoris; and by taking a particular turn, gets on the inside of the crural vein, about three fingers breadth from where it goes out of the abdomen. From its origin to this place, it is covered only by the skin and fat, and lies on the *pectineus* and *triceps primus*.

In changing its situation it sends out three considerable branches, one external, one middle, and one internal. They all go out more or less posteriorly, sometimes

sometimes by a short common trunk, sometimes by two, &c.

The external branch, called *circumflexa externa*, runs on the upper side of the thigh to the crureus, vastus externus, rectus anterior, musculus fasciae latæ, and glutæus medius; sending up a ramus to the apex of the great trochanter, which communicates with the first principal ramus of the pudica major and sciatica, as has been already said.

The middle branch, named *profunda*, runs down on the inside of the thigh between the triceps muscles; to which it gives several rami, one whereof perforates the second muscle, and is distributed to the glutæus maximus, semi-nervosus, semi-membranosus, biceps, and to the neighbouring integuments.

The internal branch, termed *circumflexa interna*, runs backward on the quadrigemini, towards the great trochanter; and having detached a ramus which goes into the joint of the os femoris, it runs downward, and gives rami to all the muscles that lie on the backside of that bone, one of which enters the bone itself on one side of the linea aspera.

Having sent off all these branches, the arteria crucialis runs down between the sartorius, vastus intermus, and triceps, giving branches to all the parts near it. It is covered by the sartorius all the way to the lower part of the thigh; and it passes through the tendon of the adductor magnus, a little above the internal condyle of the os femoris. Afterwards continuing its course through the hollow of the ham, it is called *arteria poplitea*, being accompanied by the vein of the same name.

The poplitea, while in the ham, is covered only by the integument, sending off branches toward each side, which run up upon the condyles, and communicate with the lower ramifications of the arteria crucialis.

It sends rami to the joint of the knee, called *articulares*.

*laries*, and these are distinguished into superior, middle, and inferior; one branch at least passes between the crucial ligaments. As it runs down, it sends branches to the gastrocnemii and popliteus; and having reached the backside of the head of the tibia, it gives off two branches, one to each side.

The first or internal branch surrounds the forepart of the head of the tibia, passing between the bone and internal lateral ligament; and, besides several other ramifications, sends up a small branch which communicates with the arteries that lie round the condyles of the os femoris.

The second or external branch runs over the head of the fibula, and between the head of the tibia and external lateral ligament of the knee, surrounding the articulation all the way to the ligaments of the patella, and communicating with the branches which lie round the condyles of the os femoris, together with a branch of the first or internal ramus.

Immediately after the origin of these two rami, and before the poplitea ends, it sends a small artery down on the backside of the interosseus ligament, very near the tibia, into which it enters by a particular hole a little above the middle portion of the bone.

As the poplitea ends, it divides into two principal branches; one of which runs between the heads of the tibia and fibula, passing from behind forwards on the interosseous ligament, where it takes the name of *arteria tibialis anterior*. The second branch divides into two others; one internal and largest, called *arteria tibialis posterior*; the other posterior and smallest, named *arteria peronæa posterior*.

The tibialis anterior having passed between the heads of the tibia and fibula, sends small branches upward and laterally. The superior branches communicate with those rami of the popliteus which lie round the articulation; and the lateral branches go to the neighbouring parts. Afterwards this tibial artery runs

down

down on the foreside of the interosseous ligament, toward the outside of the tibia, between the *musculus tibialis anticus* and *extensor pollicis*.

Having run laterally on the tibia for about two-thirds of the length of that bone, it passes on the foreside under the common annular ligament and *extensor pollicis*, to the articulation of the foot; giving off several rami both to the right and left hand, which communicate laterally with the *tibialis posterior* and *peronæa posterior*, so that these two bones are in a manner surrounded by arteries.

At the joint of the foot it sends out branches which run between the *astragalus* and *os calcis*, being distributed to the articulation and to the bones of the tarsus. The communications are here very numerous on all sides.

Having passed the fold of the foot, it sends off toward both sides other rami, which communicate with the *posterior tibialis* and *peronæa*; all these branches making a kind of circles round the tarsus.

Afterwards the anterior tibial artery advances on the convex side of the foot, as far as the interstice between the first and second metatarsal bones; between the heads of which it sends a large branch, which perforates the superior interosseous muscles, and, joining the *tibialis posterior*, forms an arch on the side of the foot.

It likewise sends two or three considerable branches over the other metatarsal bones, which go to the rest of the interosseous muscles, integuments, &c. and communicate with each other.

Lastly, this artery terminates by two principal branches, one of which goes to the *abductor pollicis* and inside of the great toe; the other is spent upon the outside of the great toe, and the inside of the second toe.

The *tibialis posterior*, called likewise *suralis*, runs down between the *soleus*, *tibialis posticus*, *flexor digitorum*

rum communis, and flexor pollicis; giving branches to these muscles, to the tibia, and to the marrow of that bone, through a particular canal in its posterior and upper part.

Afterwards it runs behind the inner ankle, communicating with the tibialis anterior, and surrounded by the neighbouring veins; and passes to the sole of the foot between the concave side of the os calcis and the nar muscle, where it divides into two branches, one large or external, the other small or internal.

The great branch, or arteria plantaris externa, passes on the concave side of the os calcis obliquely under the sole of the foot, to the basis of the fifth metatarsal bone, and from thence runs in a kind of arch toward the great toe, communicating there with the tibialis anterior, which perforates the interosseous muscles in the manner already said.

The convex side of this arch supplies both sides of the last three toes, and the outside of the second toe, forming small communicating arches at the end, and sometimes at the middle of each toe, as in the hand. The concave side of the arch furnishes the neighbouring parts.

The small branch, or arteria plantaris interna, having reached beyond the middle of the sole of the foot, is divided into two; one of which goes to the great toe, communicating with the ramus of the tibialis anterior; the other is distributed to the first phalanges of the other toes, communicating with the ramifications from the arch already mentioned.

The arteria peronæa runs down on the back-side of the fibula, between the soleus and flexor pollicis, to which and to the neighbouring parts it gives rami in its passage.

Having reached to the lower third part of the fibula, it sends off a considerable branch, which runs in between the tibia and that bone, passing between their extremities from behind forward, below the interosseous ligament;

ligament, and is distributed to the integuments of the tarsus.

Lastly, the peronæa continuing its course downward, on the backside of the fibula, as far as the os calcis, forms an arch with the tibialis posterior, between the astragalus and the tendo Achillis.

From thence it runs outward, and a little above the outer ankle communicates with the tibialis anterior by an arch, which sends several small ramifications to the neighbouring parts.

In this description of the arteries, we have said nothing of the cutaneous anastomoses, which are exceedingly beautiful in the fœtus; nor of the frequent and considerable communications of small arteries upon the periosteum, which form a delicate kind of net-work, or *rete mirabile*.

## C H A P. VI.

### *Of the VEINS in general.*

THE veins in many particulars resemble the arteries. There are six; of which two answer to the aorta, and the remaining four to the pulmonary artery. Some count a seventh trunk, by taking in the venæ hepaticæ. Their basis is in the ventricles of the heart, and their apices in the extremities of each branch through all parts of the body, excepting one instance in the liver; or we may reverse this order, and say the veins terminate in the heart. In a great number of parts they run parallel with the arteries, one by the side of the other; but yet they differ from the arteries in various respects.

The fabric of the veins is slender, every where smooth, difficultly separable into distinct coats or membranes, like the arteries; and the cellular texture surround-

rounding this fabric is very easily distended. This fabric, both above and below the heart, is surrounded, except in one place, with muscular fibres. Every where, however, it is lax like the cellular texture of the arteries by which they are joined to the other parts of the body. Notwithstanding this slender fabric, the veins are every where sufficiently firm, and do not easily burst with inflated air; being, in most instances, stronger than the arteries themselves. But they burst much more easily in living than in dead animals, as appears from morbid instances in the arm, face, leg, thigh, &c. Nor do they support themselves like cylinders after being divided, but they collapse together, so as to make their capacity appear like a slit; except they are sustained and hindered from thus collapsing by some stronger cellular substance placed round them, as we see in the liver and womb. They are but slightly irritable, unless the stimulus be of the chemical or more acrid classes; for, in that case, they contract themselves with a convulsive force greater than that of the arteries. They have no pulsation, if we may trust all accounts, unless the venous channel is somewhere obstructed; or when, in dying people, the blood is thrown back again from the right auricle into the descending and ascending cava, or when falling back from the brain.

The veins are much larger than their corresponding arteries, having the square of their diameter often double or triple, and almost quadruple; as near as the emulgents and vessels of the kidneys. In general, however, the diameter of the veins is to that of the arteries as nine to four; yet the capacity of the capillary veins but little exceeds that of the arteries which accompany them. They differ likewise from the arteries in their division, having more numerous trunks and branches; for to one artery in the limbs, we usually meet with two veins: and there are many veins, as the external jugular, vena portarum, azygos, cephalic,

phalic, basilic, and saphena, with which no arteries correspond. The larger veins are also branched in a more net-like disposition, by forming more frequent anastomoses one with another; for not only the smaller branches, but even the larger trunks, of the veins, are conjoined one to the other within its neighbourhood, upper with lower, and right with left, by apparent inlets or inosculations. Many of the veins, especially some of those mentioned above, affect to run near the surface of the body, and through the limbs, neck, and head: they run a long way covered with little more than the bare skin, which is a circumstance we very rarely observe in arteries; and, for the same reason, they often go out in their course to a considerable distance from the arteries. For, in this case, the veins follow the surface of the parts next the skin, without their corresponding artery, which, in the mean time, descends to a considerable depth, attended in its course by some smaller venous branch. In the smaller branches of the vessels, where they make net-like dispositions in the membranes and the internal fabric of the viscera, the veins and arteries commonly run contiguous one to the other; but here the veins have generally a less serpentine or inflected course.

In the larger sanguineous veins, valves are found in great plenty. The innermost membrane of the vein being double, rises into the cavity of the vessel like a curtain, stretching itself farther along the vein every way, so as to form what may be called a kind of crescent; but the basis, which is the part that sustains the weight of the blood, is strongest, and grows out of the vein in the shape of a circular segment. These, joined with the side of the preceding vein, intercept a space, of which the outer side is the vein itself, and the inner the valve; which, by its convexity, stands out within the bore of the vein: so that the parabolic space or hollow mouth of the valves always looks toward the heart. They are found in all the subcutaneous veins

of

of the limbs, in those of the neck, face, tongue, and in the veins of the penis : at the origin of the larger branches there are two, three, four, and sometimes five of them together, while in their smaller branches they are only single. There are none of these valves in the deep-running veins of the viscera ; and, therefore, none in those of the brain, lungs, heart or liver, or through the whole system of the vena portarum, though Wrisberg has found them in the vena portarum of many quadrupeds ; nor in the kidneys or womb (except one or two valves in the spermatic vein) ; nor, lastly, are there any in those smaller blood-veins which are of a less diameter than the twelfth part of an inch. Sometimes, though rarely, they are found in the branches of the vena azygos, and at the mouths of the hepatic and renal veins : there Dr Haller has several times observed a sort of wrinkles in the place of valves. In the smaller venous branches there are a set of long, sharp-pointed or parabolical valves, of a more extended figure as the vein is smaller : and these make a greater resistance than the larger valves, to hinder the blood from returning back upon the parts.

The veins have their origin, as we said before, from the terminations of the arteries. They sometimes arise by a continuation from the inserted branches, or from a reflection of recurved trunks of the smallest arteries. Others, again, are continued from veins less than those which carry blood ; and besides these, Dr Haller takes into account absorbing veins ; but as absorption by red veins is now denied, we lay these aside.

That there are veins of a smaller class, but resembling those which convey blood, appears from the same experiments which demonstrate the pellucid arteries : thus in the iris of the eye there are small veins, and not a few in the adnata tunica of that organ ; nor is it to be doubted, that, in a healthy body, small pellucid veins may be found in the vitreous body of the eye itself. Such have been sometimes seen by Wrisberg  
and

and others, after a fine injection or inflammation in the capsules of the lens and vitreous humour.

§ I. *Of the particular Veins.*

*Introduction.* THE blood distributed to all parts of the body by two kinds of arteries, the aorta and arteria pulmonaris, returns by three kinds of veins, called by anatomists *vena cava*, *vena portæ*, and *vena pulmonaris*.

The *vena cava* carries back to the right auricle of the heart the blood conveyed by the aorta to all the parts of the body, except what goes by the arteriæ coronariæ cordis. It receives all this blood from the arterial ramifications in part directly, and in part indirectly.

The *vena portæ* receives the blood carried to the floating viscera of the abdomen by the arteria cæliaca and the two mesentericæ; and conveys it to the *vena hepatica*, and from thence to the *vena cava*.

The *venæ pulmonares* convey to the pulmonary sinus, or left auricle of the heart, the blood carried to the lungs by the arteria pulmonaris.

To these three veins two others might be added, viz. those which belong particularly to the heart, and to its auricles, and the sinuses of the dura mater.

In describing the general course of the veins, we may either begin by their extremities in all the parts of the body, and end by the trunks carried all the way to the heart, according to the course of the blood; or we may begin by the great trunks, and end by the ramifications and capillary extremities, according to their several divisions and subdivisions.

This last method has been chosen by Winslow; and may be conveniently followed in giving a general description. But in pursuing the particular rami and ramifications, the other method seems to be the most natural, and is that to which the preference is given by

by the professor of anatomy in this university. We shall, therefore, in describing the branches, adopt the first method, and, reversing Winslow's, trace them, according to the course of the blood, from their extremities to the trunks and heart.

*General division of the vena cava.* We commonly talk of the vena cava in general, as if it were but one vein at its origin, or had but one common trunk; whereas it goes out from the right auricle of the heart by two large separate trunks, in a direction almost perpendicularly opposite to each other, one running upward, called *vena cava superior*; the other downward, called *vena cava inferior*.

It may, however, be said, that these two veins have a sort of continuity, or a small portion of a common trunk, fixed to the edges of the right auricle; as if three quarters of the circumference of a large straight tube were cut off, and the edges of a small bladder applied to the edges of the opening thus made in the tube.

The right auricle may also be looked upon as a muscular trunk common to these two large veins, and may be called the *sinus* of the *vena cava*; but in this respect, the name of *sinus pulmonaris* agrees still better to the left auricle.

The *vena cava superior* is distributed chiefly to the thorax, head, and upper extremities, and but very little to the parts below the diaphragm.

The *vena cava inferior* is distributed chiefly to the abdomen and lower extremities, and but very little to the parts above the diaphragm.

The ancients called the superior *vena cava, ascendens*; and the inferior, *descendens*; having regard only to the great tubes, and to their division into trunks and branches. Several moderns have retained these names, but in a contrary signification, to accommodate them to the motion of the blood, which descends by the *cava superior*, and ascends by the *cava inferior*.

But,

But, to shun the mistakes that may happen in reports made of wounds or other diseases, and of what is observed in opening dead bodies, and in other cases of these kinds, it is best to retain the distinction of the vena cava superior and inferior.

The trunk of each of these two veins sends off, much in the same manner with the arteries, a certain number of principal or capital branches, which are afterward ramified in different manners. Each trunk terminates afterwards by a bifurcation or a division into two subordinate trunks, each of which gives off other principal branches, ending in a great number of small trunks, rami, and ramifications.

They have likewise this common to them with the arteries, that the greatest part of the capital branches are in pairs; as well as the subordinate trunks. The ramifications of each subaltern trunk, taken by itself, are in uneven numbers; but they make even numbers, with those of the other like trunk. The vena azygos and some other small veins, of which hereafter, are exceptions from this rule.

Before we go on to the particular description of each of these veins, many of which have proper names, we shall give a general idea of their distribution, and an enumeration of their principal ramifications, in the same manner as we did in the description of the arteries, and for the same reason. But we shall say nothing of the venæ coronariæ cordis, because they are not immediately joined to any other vein, as we shall see in describing the parts of the thorax. We begin by the vena cava superior.

*Vena cava superior.* The superior vena cava runs up from the right auricle of the heart, almost in a direct course for about two finger's breadth, lying within the pericardium, in the right side of the trunk of the aorta, but a little more anteriorly.

As it goes out of the pericardium, it is inclined a little to the left hand, and then runs up about an inch,

that is, as high as the cartilage of the first true rib, and a little higher than the curvature of the aorta. At this place it terminates by a bifurcation or division into two large branches or subordinate trunks, one of which runs toward the left hand, the other toward the right.

These two branches are named *subclaviae*, as lying behind, and, in some measure, under the claviculae, both in the same manner. They are of unequal lengths, because the trunk of the vena cava does not lie in the middle of the thorax, but toward the right side, where the left subclavian arises as well as the right, and is consequently longest.

The trunk of the superior cava, from where it leaves the pericardium to the bifurcation, sends out anteriorly several small branches, which sometimes arise separately, and sometimes by small common trunks. These branches are the *vena mediastina*, *pericardia*, *diaphragmatica superior*, *thymica*, *mammaria interna*, and *trachealis*; the last of which go out sometimes behind the bifurcation.

All these small branches from the trunk of the cava superior are termed *dextræ*; and their fellows on the other side, called *sinistræ*, do not arise from the trunk, because of its lateral situation, but from the left subclavia.

Posteriorly, a little above the pericardium, the trunk of the superior cava sends out a capital branch, called *vena azygos*, or *vena sine pari*, which runs down on the right side of the bodies of the vertebræ dorsi, almost to the diaphragm; giving off the greatest part of the *venæ intercostales* and *lumbares superioris*.

The two *subclaviae* run laterally or toward each side; and terminate, as they go out of the thorax, between the first rib and clavicular, immediately before the anterior insertion of the *musculus scalenus*.

The right *subclavian*, which is the shortest of the two, commonly sends out four capital branches; the *jugularis externa*, *jugularis interna*, *vertebralis*, and

axillaris; which last is rather a continuation than a branch of the subclavia.

The left subclavian being longer than the right, for the reason already given, gives off, first of all, the small veins on the left side, answering those on the right side that come from the trunk of the superior cava, viz. the mediastina, pericardia diaphragmatica superior, thymica, mammaria interna, and trachealis.

Next to these small veins called *sinistræ*, it detaches another small branch called *intercostalis superior sinistræ*; and then four large branches like those from the right subclavian, viz. the jugularis externa, jugularis interna, vertebralis, and axillaris; which are all termed *sinistræ*.

The external jugular veins are distributed chiefly to the outer parts of the throat, neck, and head; and send a small vein to the arm, named *cephalica*, which assists in forming a large one of the same name.

The internal jugular veins go to the internal parts of the neck and head, communicating with the sinuses of the dura mater, and in several places with the external jugular veins.

The vertebral veins pass through the holes in the transverse apophyses of the vertebræ of the neck, sending branches to the neck and occiput. They form the sinus venales of these vertebræ, and communicate with the sinuses of the dura mater.

The axillary veins are continuations of the subclaviae, from where these leave the thorax to the axillæ. They produce the mammariæ internæ, thoracicæ, scapulares or humerales, and a branch to each arm; which, together with that from the external jugularis, forms the *vena cephalica*.

Afterwards the axillary vein terminates in the principal vein of the arm, called *basilica*; which, together with the *cephalica*, is distributed by numerous ramifications to all the parts of the arm, fore-arm, and hand.

*Vena cava inferior.* The portion of the inferior *vена cava*,

cava, contained in the pericardium, is very small, being scarcely the twelfth part of an inch on the fore-part, and not above a quarter of an inch on the back-part. From thence it immediately perforates the diaphragm, to which it gives the *venæ diaphragmaticæ inferiores* or *phrenicæ*.

It passes next behind the liver, through the great sinus of that viscus, to which it furnishes several branches termed *venæ hepaticæ*.

In this course it inclines a little toward the *spina dorsi* and *aorta inferior*; the trunk and ramifications of which it afterwards accompanies in the abdomen, all the way to the *os sacrum*; the *arteria cæliaca* and the two *mænentericæ* only excepted.

Thus the inferior cava sends out on each side, in the same manner with the *aorta*, the *venæ adiposæ, renales, spermaticæ, lumbares, and sacræ*. Having reached to the *os sacrum*, it loses the name of *cava*; and terminating by a bifurcation, like that of the descending *aorta*, it forms the two *venæ iliacæ*.

These iliac veins having given off the *hypogastricæ*, with all their ramifications, to the viscera of the pelvis, and to some other external and internal neighbouring parts, go out of the abdomen, under the *ligamentum Fallopii*, and there take the name of *venæ crurales*.

Each crural vein sends off numerous ramifications to all the lower extremity; besides the *vena saphena*, which goes out near the origin of the *cruralis*, and, running along this whole extremity, detaches many ramifications all the way to the foot, as we shall see more particularly hereafter.

We shall now trace the veins in the course the blood takes to the heart.

### § 2. Veins of the Head and Neck.

*Vena jugularis externa anterior.* The first branch belonging to this vein is formed of branches from each side,

side, and runs down upon the forehead, by the name of *vena frontalis*, anciently *præparata*, communicating with its fellow, when any such vein is found.

The second branch comes along the *musculus corrugator supercilii* and the upper part of the *orbicularis*, from the small or external angle of the eye, after communicating with the *vena temporalis*, and with that vein which runs along the lower part of the *orbicularis* muscle, with which it forms a kind of circle.

The third branch comes from the orbit in a winding course, on one side of the cartilaginous pulley, having communicated with the vein of the eye.

The fourth comes from the root of the nose; and communicating with its fellow from the other side, receives several small veins from the holes of the *os nastrum*.

At the great or inner angle of the eye, these branches unite to form a trunk, called *vena angularis*; which, running down near the side of the nose, receives a branch through the lateral cartilage of the nose from the internal nares, and another which ascends in a winding course from the upper-lip.

Afterwards the *vena angularis* runs down upon the face in a winding manner, receiving branches on each side from the muscles and integuments. It passes next over the lower jaw near the angle of that bone, and forms the anterior external jugular vein.

While this vein lies upon the face, the branches running into it communicate with each other, especially one which passes under the zygoma, behind the *os malæ*, from the inferior orbital or sphenomaxillary fissure; and another small branch, which runs along the inferior portion of the orbital muscle, from the small or external angle of the eye, where it communicates with the rami temporales and frontales.

It runs next down over part of the lower jaw, between the angle and the chin, like a *vena maxillaris*; and, after which, it receives several branches from the anterior, posterior, and internal parts.

Interiorly, it receives a large branch, which communicates with some branches of the jugularis interna, and receives several rami from the tongue, called *venæ raninæ*. The blood from the glandulæ sublinguales is likewise poured into it. It receives likewise a small branch from the musculus depressor anguli oris, the commissure of the lips, and the neighbouring parts.

The same branch which receives the *venæ raninæ* takes in another from the lateral parts of the septum palati, the amygdalæ, and the uvula, and receives rami forward from the membrane which lines the arch of the palate. Another branch comes into it from the pterygoidæus internus, and muscles about the palatum molle.

It is here to be observed, that, under the angle of the lower jaw, there is a great variety of communications between the external and internal jugular veins, and also a great variety in the distribution of these veins.

Almost all the ramifications, which at this place go into the external jugular vein, from the upper part of the throat and face in some subjects, terminate in other subjects in the internal jugular; and sometimes, one part of them goes to the external jugular, the rest into the internal.

The trunk of the vein, after receiving these branches, admits another large branch anteriorly from the symphysis of the lower jaw, from the maxillary glands, the digastric muscle, the chin and under-lip.

Opposite to the cartilago thyroides, it receives a transverse branch, which runs on the anterior or lower part of the musculi sterno-mastoidæi, and communicates with the jugularis of the other side, though not always by a vein of the same kind.

The superior and inferior transverse branches communicate on each side by branches more or less perpendicular, and receive a small branch from the mus-

culus

culus depressor labii inferioris and platysma myoides, and integuments.

Anteriorly, it receives several branches from the muscles of the larynx, sterno-hyoidæi, thyro-hyoidæi, and from the integuments; and below the larynx it receives communicating branches from the jugularis externa anterior of the other side.

Posteriorly, it receives, 1. A large branch on the side of the upper part of the larynx, which communicates with the jugularis interna; and likewise with a large short branch of the jugularis externa posterior. 2. A small branch, which has the same communication, but which is not always to be found. 3. Another small branch a little below the lower jaw, which communicates with the jugularis externa posterior. The trunk of the vein thus formed sometimes runs down to open into the subclavian vein; but most commonly it opens into the communication of the temporal vein, a little below the jaw.

*Vena jugularis externa posterior, sive superior.* The posterior or superior external jugular vein runs down from the side of the head, &c. receiving considerable branches from neighbouring parts.

This vein is at first formed by a branch called *vena temporalis*, which receives the blood from the temples and lateral parts of the head, likewise from some part of the occiput and forehead. Sometimes the temporal vein has two insertions, whereof one is into the jugularis interna.

The temporal vein of one side communicates above, with its fellow on the other side; before, with the *vena frontalis*; and behind, with the *vena occipitalis*. Opposite to the ear, it receives a large branch; one ramus of which runs under the lower edge of the zygoma, and then returning, communicates with another ramus from the same jugularis, a little below the condyle of the lower jaw, forming a kind of areola of a roundish form.

Behind this condyle, it receives branches from the temporal muscle, from the neighbouring parts of the upper jaw, and from the inside of the lower jaw, almost in the same manner as the arteries are sent out.

Only one of these branches comes from the *musculus temporalis* and *pterygoidæi*; communicating with a branch from the *masseter* in its passage.

Having reached a little lower, it passes through the *parotid gland*, receiving a large branch, which communicates with another branch common to the *internal* and *anterior external jugular veins*. Sometimes *areolæ* are formed through which the nerves pass. These open into the trunk by several branches. Under the angle of the lower jaw it forms communications with the *anterior external jugular*.

The trunk of the *external jugular vein*, now formed of the *external*, *maxillary*, or *facial*, and of the *temporal vein*, runs down between the *musculus platysma myoides* and *sterno-mastoideus*, being covered by the former, and crossing over the latter. In this course it receives posteriorly the *vena occipitalis*, which comes from the different parts of the *occiput*, and sometimes runs into the *vena vertebralis* or *axillaris*, &c. It likewise receives a small vein, which comes out of the cranium by the *posterior mastoide hole* from one of the lateral sinuses. This branch goes sometimes into another vein.

After receiving a branch from the *scapula*, called *muscularis* or *super-humeralis*, it ends in the *subclavian* on the same side, sometimes in the *axillaris*, and sometimes in the union of these two veins. The right and left do not always end in the same manner; for sometimes the right goes into the *subclavian*, and the left into the *internal jugular*, on the same side.

At the lower part of the neck it receives the *vena cervicalis*, which comes from the *vertebral muscles* of the neck. This vein communicates with the *humera-*

*lis*

lis by several areolæ, or venal meshes; and they are both ramified in different manners.

These ramifications and communications are in part covered by the *musculus trapezius*, and communicate likewise with some branches of the *vena occipitalis*, and with a branch of the superior intercostal vein, which perforates the first intercostal muscle.

At its termination, it receives, posteriorly, a principal branch from the muscles which cover the scapula and joint of the humerus, commonly called *vena muscularis*, and which might be named *super-humeralis*.

*Vena jugularis interna.* The internal jugular vein is the largest of all those that come from the head; tho' not so large as it seems to be when injected.

It is a continuation of the lateral sinus, which, after getting through the foramen lacerum of the basis crani, bends a little, and forms a sort of varix, which fills a thimble-like cavity in the temporal bone. From this it runs along the sides of the vertebræ of the neck, by the edges of the longus colli, and passes behind the sterno-mastoidæus and omo-hyoidæus, which it crosses, and ends in the subclavian vein. At the top of the neck it receives small twigs from the pharynx and neighbouring muscles.

Farther down it receives another branch, which comes from the occiput. This branch communicates with another of the vertebralis, and, through the posterior mastoide hole, with the lateral sinus of the dura mater. This communication is sometimes by an anastomosis with a branch of the external jugular, or of the cervicalis.

Nearly opposite to the os hyoides, the internal jugular receives another branch, which comes from the parotid gland and angle of the lower jaw, where it communicates by other branches with the two external jugulars. This first branch receives others from the muscles of the os hyoides and neighbouring parts.

About two fingers breadth lower than the former, it

receives a middle-sized branch, which comes laterally from the larynx, and may be named *vena gutturalis*.

This guttural vein is formed chiefly of three branches; the lowest of which comes from the thyroide gland and neighbouring muscles; the middle branch from the larynx, *musculi thyroidæ*, &c.; and the third runs downward from the great communication between the two jugulares already mentioned. In this, however, there is some variety; and sometimes the left guttural vein goes into the axillaris.

The last branches which it receives are small, and come from the thyroide glands.

*Vena vertebralis.* The vertebral vein accompanies the artery of the same name, sometimes in one trunk, sometimes in several stems, through all the holes of the transverse apophyses of the vertebræ colli, all the way from the great foramen occipitale, after communicating with the occipital veins and small occipital sinuses of the dura mater.

At first, it receives the veins from the vertebral sinuses, which are pretty numerous, and placed one above another, all the way from the occiput downwards, communicating freely with each other and with those on the opposite side; and at the foramen magnum occipitis, there is a communication between them and the occipital sinuses of the dura mater.

At the top of the neck it receives a branch, which comes through the posterior condyloide hole of the os occipitis from the lateral sinus of the dura mater; but it is not always to be met with.

As this vein runs through the holes in the transverse apophyses, it receives branches anteriorly from the anterior muscles of the neck, and from the small anterior muscles of the head.

Other branches come likewise from the *musculi transversales* and *vertebralis colli* at the back part of the neck.

About the third or fourth vertebra of the neck, the vertebral

vertebral vein sends off a branch, which passes out between the vertebræ, and carries down part of the blood from the neck: this communicates again with the trunk of the vertebral vein, or with the subclavian.

The trunk of the vein afterwards runs down through the holes in the transverse processes of the vertebræ colli, receiving branches in its passage from the neighbouring muscles. At the under part of the neck it leaves the vertebræ, and ends in the upper and back part of the subclavian vein.

### § 3. Veins of the Superior Extremities.

The veins of the extremities run in two sets, one following the arteries, the other running immediately under the skin; we shall trace them from their origins to their terminations in the subclavian vein.

In general, the external or superficial veins of the fore-arm are larger than the internal; but they are accompanied only by small arteries, whereas the deep veins accompany large arteries.

*Vena basilica.* This vein takes its origin by several branches which come from the convex side of the carpus; one of which, named by the ancients *salvatella*, comes from the side of the little finger next the ring-finger, having first communicated with the *cephalica*, by means of the venal areolæ conspicuous on the back of the hand. In the other fingers this vein follows nearly the same course with the artery.

After receiving these branches, it runs along the ulna, between the integuments and muscles, a little towards the outside, by the name of *cubitalis externa*, communicating with the veins called *profunda*, *satellites*, and *cephalica*. Near the inner condyle, it receives a branch which runs up along the inside of the fore-arm, near the ulna, communicating with the *mediana major*. Having reached the inner condyle, it receives a vein called *mediana basilica*, which opens into it obliquely.

Afterwards

Afterwards the basilica runs up along the inside of the os humeri, between the muscles and integuments, forming many communications with the vena profunda, satellites, and cephalica, and receiving branches from the muscles and integuments.

Below the neck of the os humeri, near the hollow of the axilla, the basilica receives two or three considerable veins which come up from the sides of the brachial artery.

These veins, which often terminate in the profunda superior, communicate with the basilica and cephalica. They follow the course of the trunks of the arteries, and have the same names. At that part of the elbow where the artery divides they unite, but afterwards separate and reunite several times, surrounding the trunk of the brachial artery at different distances, and communicating freely with each other. These veins might be called *venæ satellites arteriæ brachialis*.

Behind the tendon of the pectoralis major, the basilica receives a considerable branch, which runs up in company with the trunk of the brachial artery from the neighbouring muscles on both sides. This vein is named *profunda brachii* or *profunda superior*.

It receives at last, under the head of the os humeri, a pretty large branch, which passes almost transversely round the neck of that bone, from behind inward, and from within forward, coming from the muscles on the outside of the scapula, particularly the deltoides, and communicating with the *venæ scapularis externæ*. This branch may be named *vena sub-humeralis* or *articularis*, as the artery which lies in the same place; they both having much the same course.

This articular vein receives two principal branches; one of which runs along the inside of the bone, from which, and from the periosteum, it gets small veins. The other lies at the middle of the arm, between the bone and the biceps, and communicates with the cephalica.

The

The basilic vein having reached the side of the head of the os humeri, terminates in the trunk of the vena axillaris, which may be considered as a continuation of it.

The ancients termed the basilic vein of the right arm the *vein of the liver*, or *vena hepatica brachii*; and that of the left arm, the *vein of the spleen*, or *vena splanchnica brachii*. It has sometimes a double termination, by a branch of communication with the trunk of the axillaris.

*Vena cephalica.* The vena cephalica receives, at the extremity of the radius, branches which correspond with those of the radial artery. These branches form numerous areolæ, which communicate freely with each other.

A particular branch comes into it, which runs more or less superficially between the thumb and metacarpus, by the name of *cephalica pollicis*. The areolæ receive branches from the interosseous muscles and integuments, and communicate with the vena salvatella.

From the under part of the fore-arm the trunk of the vein runs along the radius between the muscles and integuments, receiving branches from both sides, which communicate with other branches of the same vein, and with some of the basilica, forming areolæ much in the same manner as we shall afterwards find the saphe-na does in the lower extremity. That part of the vein which lies on the fore-arm may be looked upon as a *radialis externa*.

Having reached a little below the fold of the arm, it receives a large branch, which may be called *mediana cephalica*. This comes up obliquely from the middle of the fold of the arm, under the integuments, and over the tendon of the biceps. These two medianæ are sent off in an angle, the apex of which is turned downward. The mediana cephalica sometimes receives

ceives a long branch called *radialis interna*, which lies almost parallel to the *radialis externa*.

The two median veins are sent off from a trunk which may be called *mediana major*, or *longa*, to distinguish it from the other two. This trunk runs up from the fore-arm between the *cephalic* and *basilic* veins, communicating with both in its passage by many branches. At the part where it splits into the two branches already named, a branch opens into it called *vena cubiti profunda*. This comes from the neighbouring muscles, after having communicated with the other veins of the fore-arm.

A little below the external condyle of the *os humeri*, it receives a branch posteriorly, which comes down between the *musculus brachialis* and the upper portion of the *supinator longus*, after bending between the *os humeri* and *anconæus externus*, and communicating with some branches of the *basilica*.

The *cephalica* runs next up along the outer edge of the external portion of the *biceps*; communicating several times with the *vena basilica*, and receiving small rami on each side, from the neighbouring muscles, fat, and skin. Some branches go into its upper part, which lower down were sent off from its trunk.

It runs afterwards between the *deltoid* and large *pectoral* muscles, communicating in its passage with a branch called *small cephalic*, and terminates in the *vena axillaris*.

*Vena axillaris.* This vein, formed by all the veins from the superior extremity, receives, above the *axilla*, the *venæ thoracicæ*; one of which is superior, called also *mammaria externa*; and the other inferior. It likewise receives rami from the *musculus subscapularis*, *teres major*, *teres minor*, *supra-spinatus*, *latissimus dorsi*, *serratus major*, *pectoralis minor*, *pectoralis major*, and from the glands of the *axilla*; and sometimes communicates by a small branch with the *vena basilica*.

Afterward, the last veins which it receives are the *muscu-*

musculares, which come from the middle portion of the musculus trapezius, from the angularis, infra-spi-natus, and subscapularis ; and as some of these branches come from the shoulder exteriorly, others interiorly, the venæ scapulares are distinguished into external and internal.

The axillary vein, having received the branches mentioned above, passes between the first rib and the clavicle, where it gets the name of *subclavian*; then before the anterior portion of the musculus scalenus; while it lies in the neck, receives the branches already described, from the head, neck, and upper part of the thorax; and at last meets with its fellow on the opposite side, to form the vena cava superior.

#### § 4. Veins of the Thorax.

*Venæ pectorales internæ.* The pectorales internæ, are small veins disposed in pairs toward the right and left side, behind the sternum and parts near it, including the diaphragmaticæ superiores, or pericardia diaphrag-maticæ, mediastinæ, mammariæ internæ, thymicæ, pe-ricardiæ, and gutturales or tracheales.

All these small veins are divided into right and left; and these are both distributed much in the same manner; but they differ in their terminations, because of the inequality in the bifurcation of the cava superior.

The right vena mediastina opens anteriorly into the trunk of the superior cava, a little above the termination of the azygos; the left goes into the subcla-vian.

The right superior diaphragmatica, or pericardio-dia-phragmatica, goes anteriorly to the union of the two subclavian veins, or beginning of the superior cava; and is formed by several branches from the upper, fore, and back parts of the pericardium, communica-ting with those of the left diaphragmatica, and accom-panying the nerve of the same name. The left su-pe-rior

rior diaphragmatica goes into the left subclavian a little below the termination of the mammaria.

The right internal mammaria arises from the upper and back part of the recti muscles of the abdomen; here it communicates with the epigastric vein by several small branches. It passes afterwards into the thorax under the cartilage of the last true rib, and receives small branches from the mediastinum, while others come from the integuments through between the ribs. At the upper surface of the diaphragm it receives a branch which communicates with the diaphragmatic veins. The trunk thus formed, runs up within the thorax, behind the cartilages of the ribs near the edge of the sternum, in company with the artery of the same name; and terminates at last in the beginning of the vena cava superior, but frequently in the subclavian vein.

The left internal mammaria terminates anteriorly in the left subclavian, opposite to the cartilage or anterior extremity of the first true rib.

The right vena thymica, when it terminates separately, goes into the union of the two subclaviæ; and when it is wanting, the thymus, from whence it takes its name, sends branches to the gutturalis or some other neighbouring vein. The left vein of the same name goes to the left subclavian, almost opposite to the sternum.

The right pericardia seems to go rather into the termination of the right subclavian, than to the trunk of the superior cava; but in this there are many varieties. It comes from the upper side of the pericardium, and other neighbouring parts. The left pericardia goes sometimes into the left subclavian, before the mammaria; and sometimes into the mammaria or diaphragmatica superior on the same side.

The right gutturalis or trachealis goes into the upper part of the union of the subclaviæ, above the mammaria of the same side, sometimes more backward, and sometimes into the subclavia. It comes from the glandulae

dulæ thyroidææ, trachea arteria, musculi sterno-hyoïdæi, thymus and glandulæ bronchiales. It communicates by lateral branches, more or less contorted, with the internal jugular vein; and sometimes, by another branch, with a small vein, which the internal jugular receives from the glandula thyroïdes. The left gutturalis goes into the upper or posterior part of the left subclavian near its termination.

The smallest internal pectoral veins do not always terminate separately, but have sometimes a small common trunk, especially on the right side; and of all these small veins, the mammaria interna is the most considerable.

*Vena azygos, and venæ intercostales.* The vena azygos, or sine pari, is very considerable, and arises from the lower side of the thorax internally.

For at the back part of the diaphragm, it communicates, by a very sensible anastomosis, sometimes with the vena renalis, sometimes with a neighbouring lumbar vein, sometimes immediately with the trunk of the cava inferior, and sometimes otherwise.

Winslow has seen this vein extremely large, resembling the trunk of the inferior cava, from the origin of the renales to the diaphragm; the true cava being through all this space very narrow, or of the size of an ordinary azygos.

From the left side of the thorax it runs across the spine, and afterwards ascends on the right side of the vertebræ dorsi and aorta, and before the intercostal arteries.

At the top of the thorax it is bent forward over the origin of the right lung; forming an arch which surrounds the great pulmonary vessels on that side, as the arch of the aorta does those of the left side, with this difference only, that the curvature of the azygos is almost directly forward, whereas that of the aorta is oblique. It opens posteriorly, a little above the pericardium, into the top of the superior cava.

To the above description of this vein we may add the following:

The

The azygos begins at the under part of the thorax, receives a large branch, which perforates the muscles of the abdomen : after having been ramified between their different planes, it communicates with the like ramifications of the last or last two intercostal veins.

Sometimes it receives the vena diaphragmatica inferior, and also a branch formed by the first venæ lumbares dextræ.

These communications between the last intercostal and first lumbar veins are very irregular, being sometimes by a series of opposite angles, sometimes by areolæ, sometimes by a reticular texture, &c. Sometimes the extremity of the vena azygos communicates either immediately or inmediately with the vena adiposa, and even with the vena spermatica.

The azygos receives likewise the left intercostal veins, but seldom the whole number ; for the superior veins go commonly into the left subclavian, by a vein somewhat similar to the azygos, but much smaller. The inferior intercostal veins, to the number of six or seven, sometimes more, sometimes fewer, run over between the aorta and vertebræ ; from the substance of which, and from the œsophagus, they receive capillary twigs in their way to the azygos.

Sometimes the lower left intercostals pass into a common trunk, which runs up along the left side of the vertebræ, and then crosses over behind the aorta to open into the azygos. Sabbatier calls this trunk the *demi-azygos*.

There is sometimes an entire azygos on the left side, which opens into the arch of the ordinary azygos.

As the azygos runs up in the right side of the thorax, it receives the inferior intercostal veins on that side, one coming from each series of intercostal muscles. These veins run along the lower edges of the ribs, after having perforated the muscles by branches which come from the posterior and external part of the thorax.

They communicate with the venæ thoracicæ, and most commonly with the mammaria interna; and lastly, more or less with each other, by perpendicular branches, near the posterior extremities of the ribs.

Afterwards the azygos admits into the extremity of the arch which it forms before it terminates, a trunk common to two or three small veins, called *intercostales superiores dextræ*, which bring back the blood from the first three series of intercostal muscles, and from the neighbouring part of the pleura.

These intercostal veins communicate with other branches which come through the intercostal muscles from the ferratus superior posticus, ferratus major, &c. and they run along the interstices between the ribs, communicating with the venæ mammariæ.

They likewise take in branches from the vertebral muscles and canal of the spine, where they communicate with the venal circles or sinuses, which bring back the blood from the medulla spinalis.

Lastly, the vena azygos receives two or three small veins into the top of the arch, one of which comes from the aspera arteria; the others partly from the aspera arteria, and partly from the bronchia, by the name of *venæ bronchiales*, accompanying the ramifications of the bronchial artery. It opens at last into the back part of the superior cava, a little above the pericardium.

*Vena subclaviana.* The subclavian vein is formed chiefly by veins from the head, neck, and arms. It passes over the insertion of the anterior scalenus muscle, between the clavicle and first rib.

The right subclavian, which is the shortest of the two, commonly receives four capital branches, viz. the jugularis externa, jugularis interna, vertebralis, and axillaris, of which last the subclavian may be looked upon as a continuation.

The left subclavian being longer than the right, because the vena cava, into which both open, lies in the right side of the thorax, receives first the four capital

branches, corresponding with those already mentioned, as going into the right subclavian. Next to these, it receives a vein, somewhat similar to the vena azygos, called *intercostalis superior*, which is formed of branches coming sometimes from five or six of the superior intercostal muscles, &c. these communicate with the other intercostals. The intercostalis superior receives the left bronchial vein. The subclavian receives also the small veins corresponding with those of the right side, going into the trunk of the superior cava, viz. the mediastina, pericardia, diaphragmatica superior, thymica, mammaria interna, and trachealis. And besides all these, it receives the termination of the thoracic duct, to be afterwards described.

After admitting the branches mentioned above, the two venæ subclavianæ unite at the upper end of the thorax, near the cartilage of the first rib, and form the vena cava superior, which receives the vena azygos, and runs down about an inch, somewhat inclining to the right side; at this part it enters the pericardium, and descends nearly in a direct course for about two fingers breadth in an ordinary sized person, being situated on the right side of the aorta, but a little more anteriorly. It opens at last in the upper part of the right auricle.

#### § 5. Veins of the Chylopoietic and assistant Chylopoietic Viscera.

*Vena mesaraica minor, or hæmorrhoidalis interna.* The blood sent out by the cæliac and two mesenteric arteries is returned by veins, which, as in other parts of the body, are much larger than the arteries.

A branch runs up from the rectum and left portion of the colon. The beginning of this branch communicates with other hæmorrhoidal veins at the end of the rectum. The ramifications of this vein are very numerous, surrounding the intestines, and forming arches like those of the arteries. It seems likewise to communicate

communicate by some capillary twigs with the left spermatic vein.

This vein has been named *hæmorrhoidalis*, from the tumours called *hæmorrhoides*, which are often found at its beginning next the anus. The word *interna* is added to distinguish it from the *hæmorrhoidalis externa*, which goes to the *vena hypogastrica*, but communicates with the *interna* by capillary ramifications. The name of *mesaraica minor* agrees to it very well, because of its situation with respect to the inferior mesenteric artery, which is also less than the superior.

After returning the blood from the parts already mentioned, it unites with a branch descending from the left part of the arch of the colon. This is formed by many ramifications which communicate with a branch of the great *mesaraica*, with the ramifications of the *gastro-epiploica sinistra*, and with those of the neighbouring *epiploica*.

At a small distance from its termination, it receives from the duodenum a *vena duodenalis*, which is sometimes more considerable than one which passes into the great trunk of the *vena portæ*.

The small *mesaraic* vein is one of the three principal branches of the *vena portæ*, opening commonly into the termination of the *vena splenica*, and sometimes into the beginning of the great trunk of the *vena portæ*.

*Vena splenica.* The *splenic* vein is one of the three great branches of the *vena portæ*, and may be said in some measure to be a subordinate trunk of that vein. It runs transversely from the left to the right side, first along the lower side of the *pancreas*, near the posterior edge, and then under the *duodenum*,

In this course it receives several veins, viz. the *vena coronaria ventriculi*, *pancreaticæ*, *gastrica*, or *gastro-epiploica sinistra*, and *epiploica sinistra*. It likewise often receives the *hæmorrhoidalis interna*, already described.

The vena splenica begins by branches which run in a winding course, after having run through the whole length of the spleen, almost in the same manner as the splenic artery. It is into the most posterior of these branches that the veins are received from the great extremity of the stomach, formerly known by the name of *vasa brevia*, which communicate with the coronaria ventriculi and gastrica sinistra.

In its passage it receives, at the small extremity of the pancreas, a vein called *epiploica sinistra*, because it comes from the left side of the omentum, where it communicates with the hæmorrhoidalis interna. When this vein is wanting, the branch of the left gastrica supplies its place. It sometimes goes to the most anterior branch, which the splenica receives from the spleen.

The left gastric or gastro-epiploic vein, coming from the convex side of the great extremity of the stomach, goes into the splenica at the left extremity of the pancreas.

In its passage, it receives several branches from both sides of the stomach, which are distributed by numerous ramifications, forming many areolæ, and communicating with the branches of the coronaria ventriculi.

The vene pancreaticæ are several small branches sent into the splenica from the under edge of the pancreas. There are other small pancreatic veins which do not open into the splenica, as will be found in the description of the gastro-colica, one of the branches of the great mesenteric trunk.

The coronaria ventriculi, so called because it surrounds more or less the upper orifice of the stomach, runs along the small arch of that viscus from the pylorus, where it joins and becomes continuous with the vena pylorica. In its passage, it receives several rami from the sides of the stomach, which there form numerous

merous areolæ, and communicate with the veins of the great arch.

It terminates pretty often in the beginning of the splenica, and sometimes in the left side of the beginning of the great trunk of the vena portæ, behind the hepatic artery; and in that case it is the most considerable of all the small veins that go into the great trunk.

*Vena mesaraica major.* The blood is returned from most of the branches of the superior mesenteric artery by a vein called *mesaraica* or *mesaraica major*, which runs up to the inferior vena portæ, and appears in some measure to form it. As it runs along it forms an arch almost like that of the artery, which is likewise ramified on both the concave and convex sides; but not so regularly: returning the blood from the small intestines, the cæcum, and right portion of the colon.

Into the concave side of the mesaraic vein, passes a branch called by Riolan *vena cæcalis*, which runs from the beginning of the colon, crossing one of the branches of the superior mesenteric artery.

This cæcal vein is formed by two arches, the uppermost of which communicates with the lower branch of the vena gastro-colica; the other receives ramifications from the intestinum cæcum and appendicula vermicularis, and communicates below with other branches of the great mesaraic vein.

Afterwards the trunk of the mesaraica passes over the superior mesenteric artery, to which it adheres very closely; but previous to this it receives several branches into the convex side of its arch almost in the same manner with the artery; but with this difference, that frequently the branches do not end immediately in the vein in so great numbers; and each of them is formed by many more ramifications.

The trunk of the great mesaraic vein receives sometimes opposite to the gastrica, a particular branch from the omentum, called *epiploica dextra*. But almost im-

mediately after it descends over the mesenteric artery, it gets the addition of two large branches very near each other, which pass behind and under the artery, coming from the jejunum and part of the ilium by numerous ramifications, which form arches and areolæ like those of the artery.

The trunk of the great mesenteric vein running farther, receives a vein which may be called *gastro-colica*; this is formed of two branches, one superior, the other inferior.

The superior branch of the *vena gastro-colica* receives the *gastrica*, or *gastro-epiploica dextra*, which comes from the great curvature of the stomach, communicating with the *gastrica sinistra*. It also admits small veins from the head of the pancreas. In its passage it gets likewise branches from the stomach and omentum, and communicates with the *pylorica*, *coronaria ventriculi*, &c. and sometimes it receives the *pylorica*.

The inferior branch of the *vena gastro-colica*, which may be called *colica dextra*, comes from the upper part of the colon, and then from the right portion of that intestine, where it is divided archwise, and communicates with the great branch of the *colica anterior*, and with a branch of the *vena cæcalis*.

The last particular branch running into this trunk is called by Riolan *vena colica*. It opens into the anterior part of the trunk, before it joins the artery, and comes directly from the middle of the colon; and here it is formed of branches from the right and left, which communicate with others by arches. On the left hand, it communicates with the superior or descending branch of the *hæmorrhoidal*; and on the right, with the former branch of the *mesenterica*.

The vein, after having been distributed like the artery, runs through those parts of the mesentery and mesocolon which belong to the small intestines, the cæcum, and right portion of the colon; it passes next over

over the trunk of the arteries, receiving in its way the splenic vein, and terminates at last in the vena portæ.

The vena portæ inferior appears to be a continuation of the trunk of the vena mesaraica major. The splenica is a capital branch of that trunk; and the hæmorrhoidalis interna has sometimes a common termination with the splenica, and sometimes is no more than a branch of that vein. In some subjects the mesaraica major and splenica appear to end by an equal union in the trunk of the inferior vena portæ, and in others the hæmorrhoidalis ends in the very angle of that union.

*Vena portæ.* The inferior vena portæ, after being formed of the splenic and mesenteric veins, receives into its trunk several small rami, which are commonly the venæ cysticæ, hepatica minor, pylorica, duodenalis, and sometimes the gastrica dextra, and coronaria ventriculi.

All these small veins sometimes end separately; and in other subjects, some of them go into it by small common trunks. It sometimes happens that several of them do not go immediately into the trunk of the vena portæ, but into one of the branches which form it.

The trunk composed of the two mesenterics and splenic veins passing on receives the vena gastrica, or gastro-epiploica dextra, and the coronaria ventriculi, but these go sometimes into some of the larger branches.

The duodenal vein, commonly called *vena intestinalis*, goes into the great trunk near the cysticæ, and sometimes into the small common trunk of these veins. It comes chiefly from the intestinum duodenum, and receives likewise some rami from the pancreas. There is another vein called also *duodenalis*, which terminates in the gastrica of the same side.

The vena pylorica terminates in the great trunk, almost opposite to the end of the cysticæ, and sometimes goes into the right gastrica. It passes over the

pylorus from the short arch of the stomach, where it is joined by anastomosis with the coronaria ventriculi.

The cystic veins run along the vesicula fællis from its bottom to its neck; and as they are commonly no more than two in number, they are called *cysticæ gemelleæ*, a name given likewise to the arteries which accompany them. They go into the right side of the great trunk near its end, sometimes separately, sometimes by a small and very short common trunk.

The small hepatic vein is commonly a branch of one of the *cysticæ*, or of their common trunk.

The large trunk of the *vena portæ inferior* or *ventralis*, is situated under the lower or concave side of the liver, and joined by an anastomosis to the sinus of the *vena portæ hepatica*, between the middle and right extremity of that sinus, and consequently at a good distance from the left extremity. From thence it runs up a little obliquely from left to right, behind or under the trunk of the *arteria hepatica*, its length being about five fingers breadth.

At the head of the pancreas, this trunk may be said to begin by the three branches already described.

The last portion of this vein may be termed *vena portæ hepatica*, superior or minor, the trunk of which is commonly known by the name of *sinus venæ portarum*. The other portion may be called *vena portæ ventralis*, inferior or major.

The *vena portæ* may be considered as made up of two large veins, joined almost endwise by their trunks, from each of which the branches and ramifications go out in contrary or opposite directions. One of these parts comes from the stomach and intestines, with the spleen and pancreas, and has been already described; the other goes to the liver.

*§ 6. Veins of the Inferior Extremities.*

THE blood is returned from the inferior extremities by a superficial and deep set of veins, somewhat in a similar manner to what we have described in the superior extremities. Of the superficial veins we find one called *saphena major*, and another called *saphena minor*. The deep veins have the same names with the arteries which they accompany.

*Vena saphena major.* This begins at the great toe, then runs between the first two metatarsal bones irregularly under the skin towards the inner ankle.

At the great toe it receives a kind of transverse arch over the metatarsus, which communicates by several branches with an arch which lies on the joint of the tarsus, and gets others from the toes. This arch receives likewise another branch, which runs down behind the outer ankle, having communicated with the *vена tibialis externa*.

Under the inner ankle, it receives a branch inward and forward, which runs under, and in some measure accompanies, the anterior tibial artery. Internally, it receives another branch at the same place, which passes up from the sole of the foot, communicating with the external tibial vein by irregular arches. This in its passage receives branches from the toes.

At the lower part of the tibia, the *saphena* receives a considerable branch, which runs obliquely from the outer ankle, being formed of several rami, which communicate with each other and with the trunk of the *saphena*.

A little higher, it likewise receives from the fore-part of the tibia some branches coming from the periosteum and bone, and communicating with other branches to be described.

Afterwards the trunk of the great *saphena* runs upon the inside of the tibia, lying always near the skin; at

the

the middle of the tibia, a vein forms an arch which communicates at both ends with the trunk of the large vein. A branch running up from the outer ankle along the integuments of the tibia, and communicating with the saphena, passes into this arch. At the upper part of the bone, it receives branches forward, outward, and backward.

The anterior branches come from the integuments on the upper part of the leg; the posterior, from those which cover the gastrocnemii, and communicate with the little saphena; and the external branches come from the fat and integuments.

From the leg the saphena passes along the inside of the knee, and afterwards along the thigh, as far as the middle of the sartorius muscle; and here it receives from the same side several branches, which in their passage communicate with each other.

The vena saphena passes afterward to the forepart of the thigh, having been covered in all its passage by skin and fat only. At the groin it receives branches from the inguinal glands and neighbouring parts: these form free communications with each other. It opens at last into the top of the femoral vein.

*Vena saphena minor.* The vena saphena minor returns the blood from the outer side of the foot by many small branches, which communicate freely with each other. From this part it runs up at the outside of the tendo Achillis; and, next, between the gastrocnemius externus and skin.

Immediately above and below the ham, this vein receives branches, which likewise communicate with each other, and with the saphena major.

At the ham, a branch forms a communication between it and the crural vein, receiving small anastomosing branches in its ascent. It terminates at last a little above the ham in the trunk of the vena poplitea.

*Vena tibialis anterior.* From the extremities of the anterior tibial artery, the corresponding vein returns, first

by

by a number of origins: but these, at the bottom of the leg, unite into one trunk; which, however, soon splits again into two or three branches, that surround the artery at different distances by small communicating circles. A particular branch, which communicates with the vena tibialis posterior, perforates the interosseous ligament from behind forward, and opens into the trunk of the vein at the bottom of the leg.

At the upper end of the leg the vein receives small superficial branches from the head of the tibia and fibula, which come from the joint of the knee, communicating there with lateral branches of the vena poplitea. It then perforates the head of the interosseous ligament, and terminates in the vena poplitea.

*Vena tibialis posterior.* From the sole of the foot the venæ plantares return after being formed of several transverse arches, which communicate with each other and with the saphena, and receive ramifications from the toes, nearly in the same manner as the arteria plantaris.

The venæ plantares form a trunk, which passes on the inside of the os calcis, and then behind the inner ankle as high as the ham. At the lower part of the leg, it communicates with a transverse branch of the saphena, and with the anterior tibial vein, in the manner already said; then receives branches from the musculus tibialis posticus and the long flexores of the toes.

Afterward the posterior tibial vein runs up between the soleus and tibialis posticus, receiving branches from each of them. It is formed, somewhat in the same manner as the tibialis anterior, of two or three branches, which, as they run, surround the corresponding artery, by small communicating circles formed at different distances.

It receives near its termination a branch, called *suralis*, from the gastrocnemii and soleus; and opens at last into the vena poplitæa, a little lower than the tibialis anterior.

*Vena peronæa.* The vena peronæa is likewise double,  
and

and sometimes triple. It runs up on the inside of the fibula, almost in the same direction with the arteria peronæa, which it likewise surrounds at different distances, by communicating branches, after the manner of the tibialis posterior, and like it ends in the vena poplitea.

It runs up from the foot to near the joint of the knee, communicating several times with the tibialis posterior, and receiving ramifications from the neighbouring portions of the musculi peronæi and long flexors of the toes.

The first of these communications make the venæ plautares, in some subjects, to appear rather to go into this vein, than into the tibialis posterior, where they commonly terminate.

*Vena poplitea.* The vena poplitea, formed of the three large veins last described, but appearing to be a continuation of the tibialis posterior, runs up immediately behind the muscle of the same name; at the lower part of which it receives several ramifications from each side, which divide and unite again in different ways and degrees before they terminate.

Near the internal condyle of the os femoris, the poplitea receives some lateral branches from the extremities of the neighbouring muscles, especially those of the semi-nervosus, semi-membranosus, &c. A branch which comes off from the trunk a little way below, and runs along the peronæus longus, likewise goes into it.

It also receives several other branches; one of which comes laterally between the outer condyle and the biceps, having been ramified in the same manner with the artery. Another branch runs up on the back-side of the gastrocnemii muscles from the tendo Achillis; then it goes forward, receiving ramifications from the beginning of these muscles. And now running up betwixt the two condyles, it receives branches from the flexor muscles of the leg, from the lower and posterior parts of both vasti, and from the fat which lies above

the

the interstice of the two condyles. A little above the ham, it gets the name of *crural vein*.

The crural vein runs up between the biceps and other flexors of the leg, closely accompanied by the crural artery; between which and the inner condyle of the os femoris it is situated. A little above the ham it receives the *vena saphena minor* from the back part of the leg. Near about the same place the crural vein sends out a branch which runs up on the side of the trunk covering the crural artery, as high as the upper extremity of the *vastus internus*, where it is again united to the trunk by anastomoses; but sometimes this trunk takes its origin in the upper part of the leg.

It has the name of *vena sciatica* from the sciatic nerve which it accompanies. The trunk of the vein runs now up on the thigh behind the crural artery, till it gets opposite to the trochanter minor, where it receives the *circumflexa externa*, *circumflexa interna*, and *profunda femoris*; the distribution of which is similar to that of the corresponding arteries. In this course, other small veins run in from different parts of the thigh; but these have no particular names.

About an inch below Poupart's ligament, the crural vein receives the *saphena major*; and then branches from the inguinal glands, the *musculus pectineus*, and parts of generation. These are termed *pudicæ externæ*, and evidently communicate with internal veins of the same name. After this the trunk of the vein goes into the abdomen under Paupert's ligament, on the inside of the corresponding artery.

#### § 7. Veins of the Pelvis.

*Vena iliaca externa.* After the crural vein gets from under the *ligamentum Fallopii*, it is called *vena iliaca externa*; this receives several small rami from the neighbouring lymphatic glands.

To the inside, after it gets into the abdomen, it receives

ceives the vena epigastrica; which runs down along the back part of the musculi recti, from which it chiefly comes; but receives also branches from the broad muscles of the abdomen, which penetrate from without inwards: near its termination, it gets small branches from the conglobate glands.

The beginning of the vena epigastrica runs downward, from the ramifications of the mammaria, with which it communicates, accompanying the epigastric artery. At the inside of the epigastric vein, a branch is sometimes received from the musculus obturator internus, where a communication is also made with the vena obturatrix.

Near the end of the former vein, the iliaca externa receives a branch which comes down along the inside of the crista of the os ilium; and admits others on each side, from the lateral and posterior lower portions of the musculi abdominis, from the musculus iliacus, &c. So that the external iliac vein, lying on the psoas and iliac muscles, receives almost the same branches with the artery of the same name, and follows the same course.

After admitting the branches already mentioned, the trunk of the vein joins a large vein from the cavity of the pelvis called *vena iliac interna*, or *hypogastrica*.

*Vena iliac interna.* The hypogastric or internal iliac vein, runs behind the artery of the same name, making the same kind of arch, into which the following branches open.

Of the branches which form the hypogastric vein, we find first a large branch running from the lower part of the os sacrum, and two or more which come upward through the notch of the os ilium from the buttocks, anus, neighbouring portion of the musculus pectineus, and from the external parts of generation, nearly in the same manner with the artery which accompanies them.

The veins that come from the anus, are termed *haemorrhoidales*

*morrhoidales externæ*; and those that come from the parts of generation, *pudicæ internæ*. The external hemorrhoidales communicate with the internal veins of the same name, which go to the small *vena mesariaca*, one of the branches of the *vena portæ*.

The hypogastric vein receives branches which come into the pelvis, above the superior sacro-sciatic ligament; and before they come in, they are ramified chiefly upward and downward.

Within the pelvis it receives a large branch called *vena obturatrix*, which comes through the foramen thyroideum from the obturator muscles, *adductores femoris*, and neighbouring parts.

The *vena obturatrix*, after it perforates the muscles, receives branches exteriorly from the *musculus iliacus*, the superior part of the *obturator internus*, and from the *os ilium*, near its symphyseis with the *os ischium*.

Interiorly, the same obturator vein receives another branch, which comes from the ureters, bladder, and internal parts of generation in both sexes. It communicates with the spermatic veins, and is more considerable in women than in men.

Into the posterior or convex part of the arch, the iliac vein receives a branch from the superior lateral part of the *os sacrum*, which comes from the *musculus faser*, or lower part of the *multi fidus spinæ*, and other muscles near it, and from the cavity of the bone, passing through the first great hole.

A little lower, on the same side, it receives another, which comes much in the same manner with the former, through the second hole.

Into the external lateral part of the same arch, a little anteriorly, it receives a large branch, which runs behind the great sciatic sinus, and comes from the *musculi glutæi*, *pyriformis*, and *gemelli*. After receiving these different branches, it joins the external iliac vein.

*Vena iliaca communis*. The hypogastric vein, running up in the pelvis, joins the external iliac to form

the common iliac vein, in the same manner that the iliac arteries are connected with the aorta; but the union is about a finger's breadth lower than the bifurcation of the aorta.

The external vein in adults seems to be in a line with the common iliac, and the hypogastrica only a branch; but in the foetus there is a considerable variation.

These veins follow nearly the course and distribution of the iliac arteries, except that the hypogastric vein does not receive the vena umbilicalis. The external iliac veins lie more or less on the inside of the arteries, in the manner already said; but the hypogastric veins, in the bottom of the pelvis, lie almost behind the arteries on the same side.

To the common trunk of the iliac veins, and sometimes to the origin of the iliaca externa, a particular branch comes in from the musculus psoas, iliacus, and quadratus lumborum; some of which communicate with the last lumbar vein.

### § 8. Veins on the Back-part of the Abdomen and Loins.

THE two common iliac veins unite to form the vena cava. Into this union, and often into the end of the left iliaca, the vena sacra goes in, having accompanied the artery of the same name in its distribution to the os sacrum, to the nerves which lie there, and to the membranes which cover both sides of that bone.

The extremity of the trunk of the vena cava, lies in some subjects behind the origin of the right iliac artery; in others, it is the left iliac vein which passes there, and consequently crosses the right iliac artery. The cava passes up through the abdomen on the forepart of the lumbar vertebrae, and on the right side of the aorta.

It receives posteriorly the venæ lumbares; which commonly end in pairs, in the same manner as the corresponding

corresponding arteries go out from the aorta. These may be divided into superior and inferior veins.

Their terminations vary in different manners. Sometimes the cava receives a branch from each side below the first vertebra of the loins, which, like a common trunk, receives the lumbar veins. This branch communicates with the azygos.

Sometimes a considerable branch comes into the lower extremity of the cava, near the union, chiefly on the right side; which, having run down between the bodies and transverse apophyses of the vertebræ, receives the *venæ lumbares*, and communicates with the azygos.

Sometimes a like branch goes to the beginning of the left *vena iliaca*; and having run down on that side in the same manner, admits the *lumbares*. This branch likewise communicates with the azygos, and with the superior or descending *ramus lumbaris*.

The *venæ lumbares* on one side communicate by transverse branches with those of the other side, and likewise with each other by branches more or less longitudinal. The first and second often go to the azygos, and thereby they communicate with the intercostal veins.

The lumbar veins come from the muscles of the abdomen, *quadratus lumborum*, *psoas*, *iliacus*, &c. and they receive small branches in their passage from the substance of the bodies of the vertebræ. They get branches forward from the neighbouring vertebral muscles, and from the canal of the spine, and communicate with the venal sinuses in the same manner as the intercostals do.

Having got as high as the arteriæ renales, the *vena cava* receives the veins of the same name, termed formerly *venæ emulgentes*, and which are the largest of all the veins that go to the *cava inferior*; from the beginning to the part where it runs behind the liver.

The right renal vein is the shortest, and runs up a little

little obliquely because of the situation of the kidney. The left vein, which is the longest, crosses on the fore-side of the trunk of the aorta, immediately above the superior mesenteric artery, and both veins accompany the renal arteries.

They receive the venæ capsulares which come from the glandulæ renales, and branches from the venæ adiposæ which come from the fatty covering of the kidneys; and ordinarily the left renal vein receives the left spermatic vein.

A little below the renal veins, the trunk of the cava receives anteriorly the right vena spermatica. The left spermatic vein goes commonly, though not always, to the left renales. Both veins accompany the corresponding arteries.

In their passage, they receive several small branches on each side, from the peritonæum and mesentery; where they seem to be joined by anastomoses with the venæ mesentericæ, and consequently with the vena portæ.

They sometimes bring a considerable branch over the iliac muscle, which is formed of two others; one ramus runs down from the membrana adiposa of the kidneys, the other runs up on the last mentioned muscle.

About the same height with the spermatic vein, the inferior cava receives posteriorly, in some subjects, a branch which runs downward, after communicating with the vena azygos. Sometimes this branch goes into one or other of the renales, and appears to be a true continuation of the extremity of the azygos.

Behind the liver the vena cava receives the venæ diaphragmaticæ or phrenicæ, which come from the diaphragm, and appear chiefly on its lower side, one towards the right hand, the other towards the left. The right vein is more backward and lower than the left. The left comes partly from the pericardium, and partly from the diaphragm; and sometimes they receive

ceive rami from the capsulae renales, which correspond with branches sent out by the arteriae phrenicæ.

The inferior cava passes next through the posterior part of the great fissure of the liver, penetrating a little into the substance of that viscus, between the great lobe and the lobulus Spigelii; being, however, covered but very little, on the backside, by the substance of the liver, after it reaches the lobulus.

In its passage, it receives commonly three large branches, called *Venæ hepaticæ*, which are ramified in the liver. Sometimes there are only two, and sometimes four.

Besides these large branches, it receives some other small ones, either before or immediately after it enters the liver; which, according to some anatomists, answer to the branches of the hepatic artery, as the large branches do to those of the vena portæ.

In the foetus, as the vena cava passes by the liver, it receives the ductus venosus, which communicates with the sinus of the vena portæ, and in adults is changed to a flat ligament.

The vena cava having received these branches, perforates the tendinous portion of the diaphragm and the pericardium; and upon running a quarter of an inch or so within the pericardium, opens into the under part of the right auricle.

#### EXPLANATIONS OF TABLES XI. AND XII.

TAB. XI. *Represents the Heart and Blood-vessels.*

A, The heart.

B, The aorta ascendens.

C, A trunk from which the right subclavian and right carotid arteries are sent off. (Those on the left side come off separately.) The subclavian artery passes

over to the arm behind the subclavian vein. The carotid artery runs up to the head, partly covered by the internal jugular vein.

*D*, The facial artery, which sends off the coronary arteries of the lips.

*E*, The deep temporal artery.

*F*, The descending aorta.

*G*, The right common iliac artery, which divides into the external and internal iliacs.

*H*, The femoral artery, which is a continuation of the external iliac artery.

*I*, The anterior tibial artery, sending branches to the forepart of the leg and upper part of the foot.

1, The frontal vein running down to form

2, The facial vein.

3, Deep temporal vein.

4, Occipital vein.

5, The external jugular vein.

6, The internal jugular vein, lying on the outer and fore part of the common carotid artery.

7, An arch on the palm of the hand, which runs partly to

8, The radial vein, and partly to

9, The ulnar vein. The two last veins run close by the sides of their corresponding arteries.

10, The cephalic vein.

11, The basilic vein cut. On the left side it is entire.

12, Branches running up to form

13, The humeral vein.

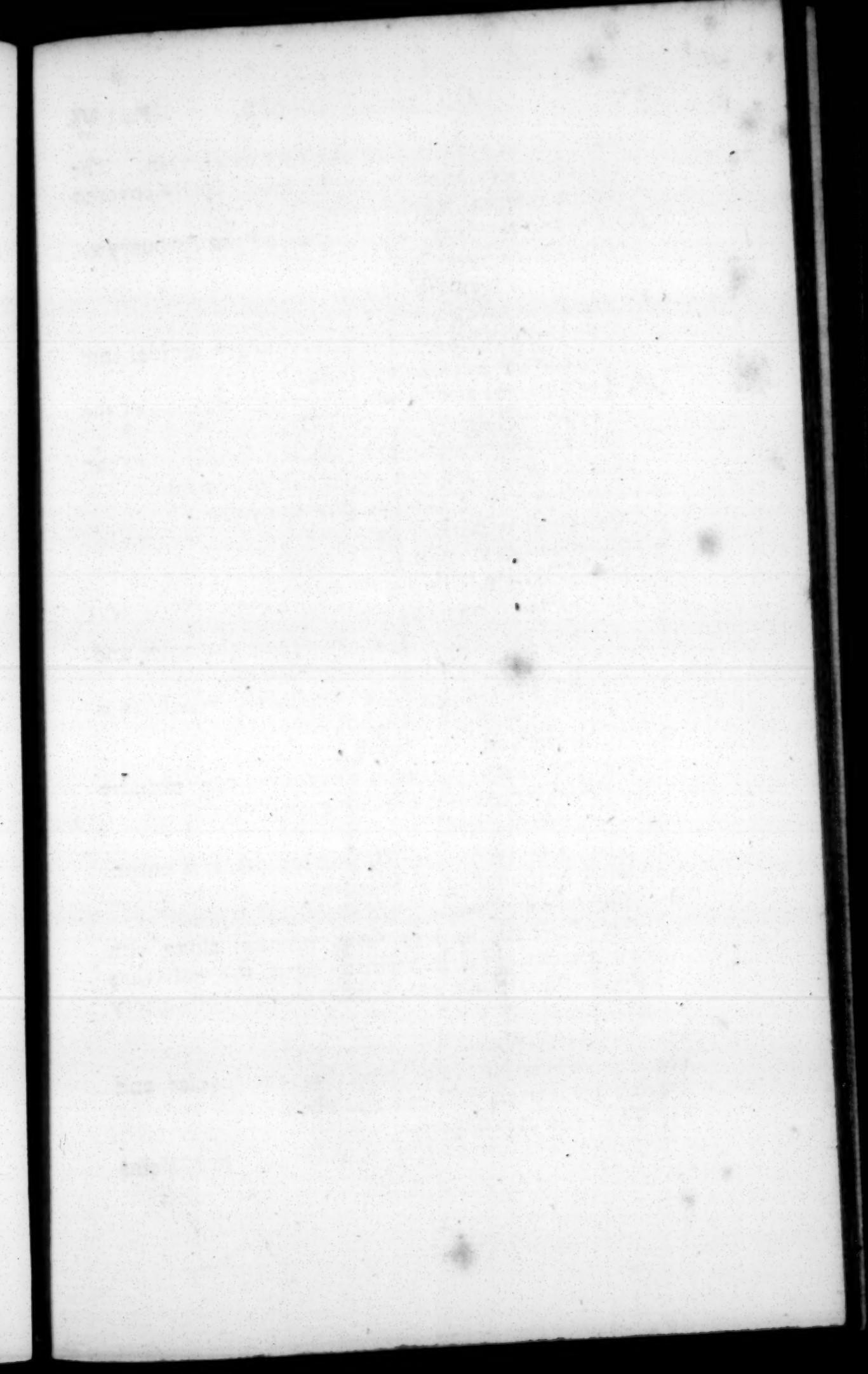
14, The external thoracic veins running along with their arteries. [N B. In many parts, the vessels are so small, that one trunk must represent both artery and vein.]

15, The axillary vein.

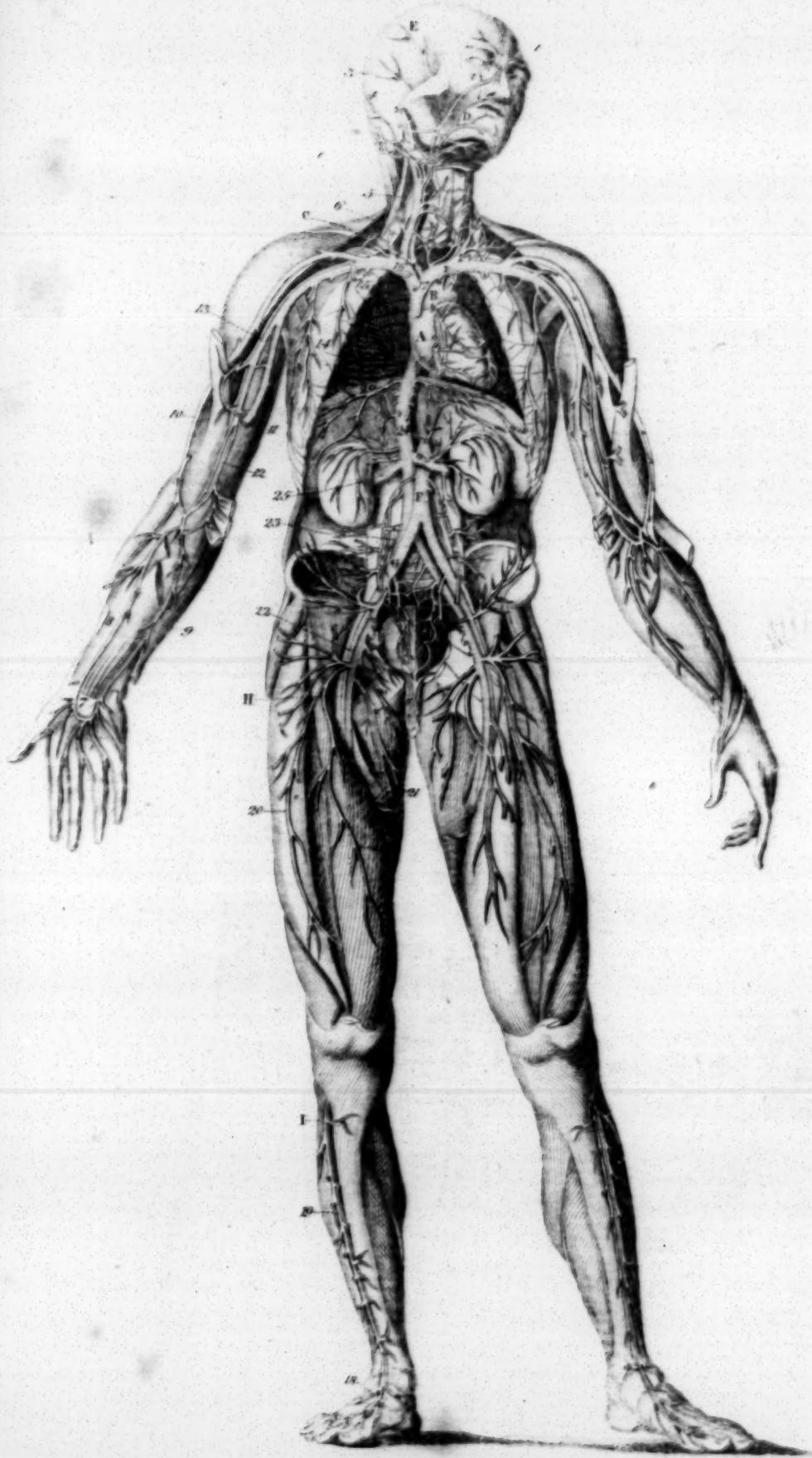
16, The subclavian vein, receiving the jugular and other veins from the head and neck.

17, The vena cava superior.

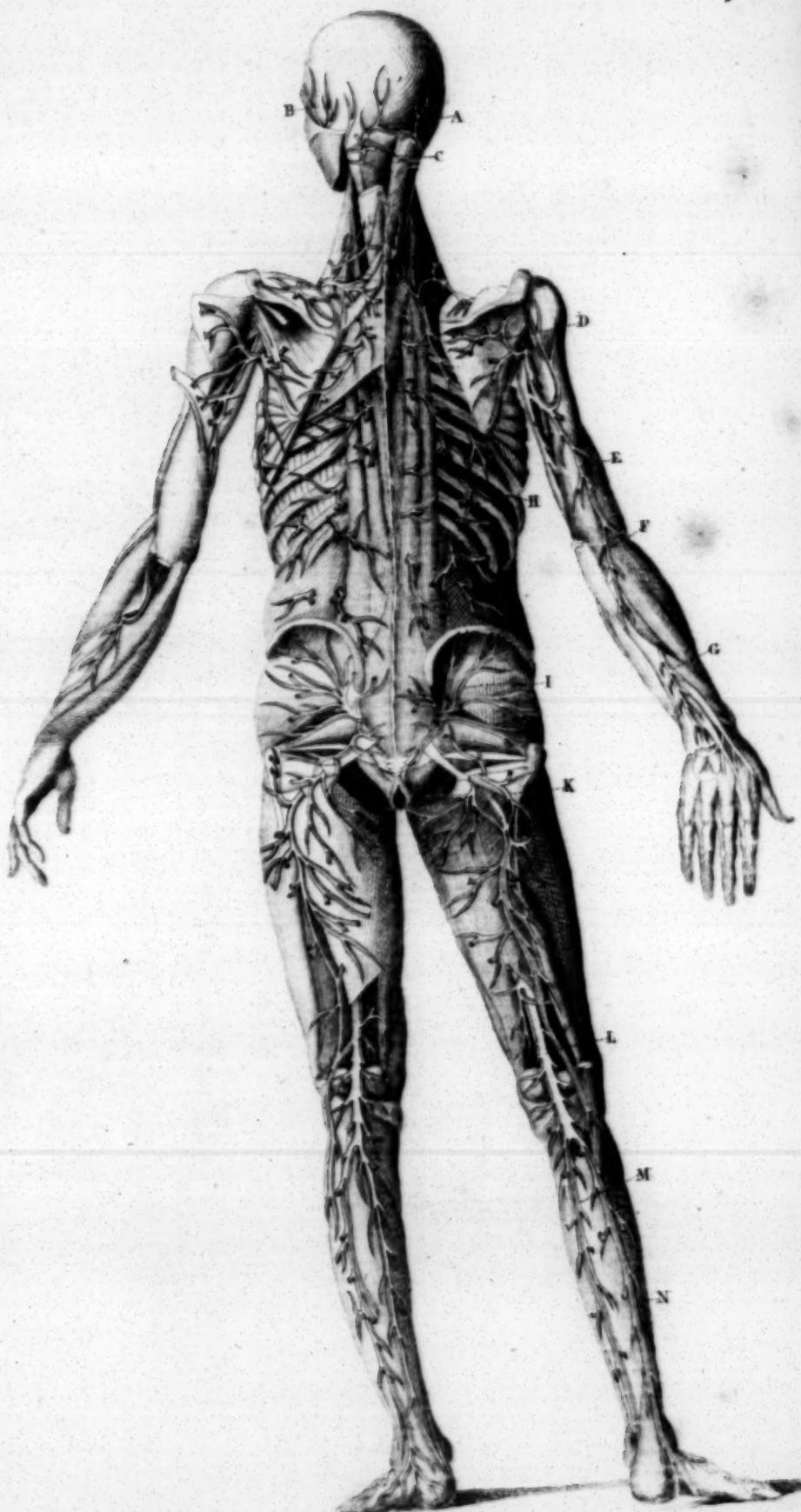
18, Veins

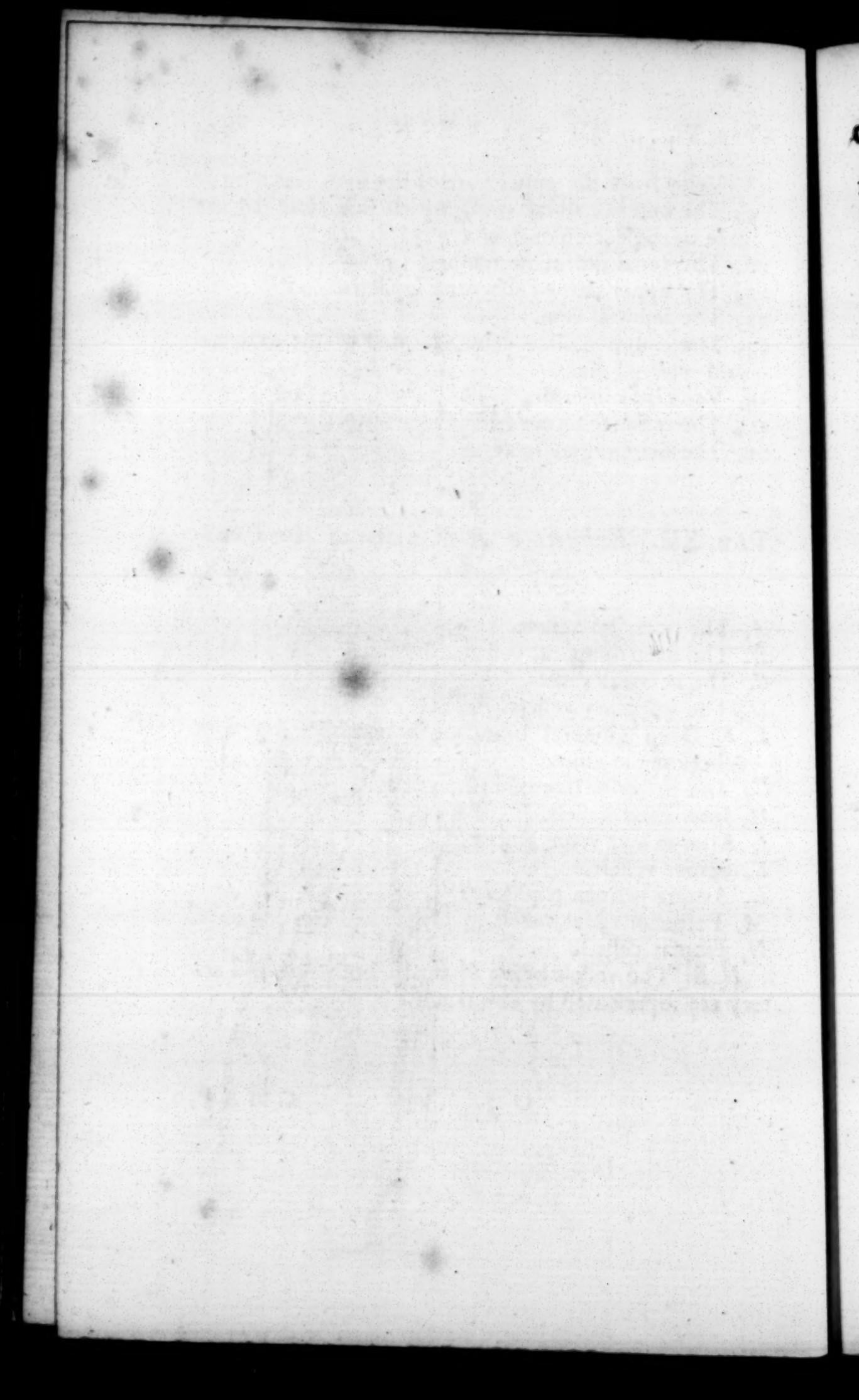


TAB. XI.



TAB. XII.





- 18, Veins from the upper part of the foot, forming
- 19, The anterior tibial vein, which lies close by the side of the corresponding artery.
- 20, The venæ profundæ femoris.
- 21, The upper part of the vena saphena.
- 22, The femoral vein.
- 23, The common iliac veins, formed of the external and internal iliacs.
- 24, Vena cava inferior.
- 25, The renal veins covering the arteries.
- 26, The diaphragmatic veins.

TAB. XII. *Exhibits a Back-view of the Blood-vessels.*

- A, The occipital vessels.  
B, The deep temporal vessels.  
C, The cervical vessels.  
D, The scapular vessels.  
E, F, Deep humeral branches communicating with others at the elbow.  
G, The posterior interosseous vessels.  
H, Intercostal vessels.  
I, Arteriæ and venæ gluteæ.  
K, Sciatic vessels.  
L, Arteria et vena poplitea.  
M, Posterior tibial vessels.  
N, Fibular vessels.

N. B. The vessels being so small, both vein and artery are represented by one trunk.

## C H A P. VII.

*Of the ABSORBENT SYSTEM.*

FOR the discovery of the principal parts of this system, we are chiefly indebted to Asellius, Pecquet, Rudbeck, Jolyffe, and Bartholine. Some of the vessels of which it consists had been indeed seen and mentioned by their predecessors, but it was in too cursory a manner to give them any title to the discovery. Thus the lacteals had been seen in kids by Erasistratus, who calls them *arteries*, as we are informed by Galen: And the thoracic duct had been seen by Eustachius, who speaks of it as a vein of a particular kind; (see Eustachius *de Vena sine Pari.*)

In 1622, Asellius discovered those vessels on the mesentery, which, from their carrying a milk-like fluid, he denominated *lacteals*. This discovery being made by opening a living dog, anatomists were thence encouraged to make experiments on living animals; and Pecquet, on opening a dog in the year 1651, found a white fluid mixed with the blood in the right auricle of the heart. Suspecting this fluid to be chyle, he endeavoured to determine how it got from the lacteals into the heart: this he found was by means of the ductus thoracicus, which he traced from the lacteals to the subclavian vein; and thus he clearly proved the existence of that duct which we now consider as the trunk of the system. Just before this time the lacteals had been supposed to terminate in the liver; conformably to the idea which the physiologists of that period had adopted about the use of this organ, which, from the authority of the older anatomists, they believed was

was the viscus *haemopoeticum*, or received the chyle from the intestines to convert it into blood.

In the years 1651 and 1652, Rudbeck, Jolyffe, and Bartholin, discovered the other parts of this system, which, from their carrying a transparent and colourless fluid, are called the *lymphatic vessels*. Thus there was proved to exist in an animal body a system of small vessels containing fluids very different from the blood, and opening into the sanguiferous vessels at the left subclavian vein.

After this period, Nuck added to our knowledge of this system, by his injections of the lymphatic glands; Ruysch, by his description of the valves of the lymphatic vessels; and Dr Meckel, by his accurate account of the whole system, and by tracing those vessels in many parts where they had not before been described.

Besides these authors, Drs Hunter and Monro have called the attention of the public to this part of anatomy, in their controversy concerning the discovery of the office of the lymphatics.

When the lymphatic vessels were first seen and traced into the thoracic duct, it was natural for anatomists to suspect, that as the lacteals absorbed from the cavity of the intestines, the lymphatics, which are similar in figure and structure, might possibly do the same office with respect to other parts of the body: and accordingly, Dr Glisson, who wrote in 1654, supposes these vessels arose from cavities, and that their use was to absorb; and Frederic Hoffman has very explicitly laid down the doctrine of the lymphatic vessels being a system of absorbents. But anatomists in general have been of a contrary opinion; for from experiments, particularly such as were made by injections, they have been persuaded, that the lymphatic vessels did not arise from cavities, and did not absorb, but were merely continuations from small arteries. The doctrine, therefore, that the lymphatics like the lacteals,

were absorbents, as had been suggested by Glisson and by Hoffman, has been revived by Dr Hunter and Dr Monro, who have controverted the experiments of their predecessors in anatomy, and have endeavoured to prove that the lymphatic vessels are not continued from arteries, but are absorbents.

To this doctrine, however, several objections have been started, particularly by Haller, (Elem. Phys. I. 24. § 2, 3.) ; and it has been found, that before the doctrine of the lymphatics being a system of absorbents can be established, it must first be determined, whether this system is to be found in other animals, besides man and quadrupeds. Mr Hewson claims the merit of having proved the affirmative of this question, by discovering the lymphatic system in birds, fish, and amphibious animals. See Phil. Trans. vol. 58. and 59.

### Section I. *Of the Absorbent System in general.*

THE absorbent system consists of the lacteals, the lymphatic vessels, their common trunk, the thoracic duct, and the glands called *conglobate*.

The lacteals begin from the intestinal tube, and can for the most part be seen in a dog or other large quadruped that is killed two or three hours after eating, when they appear filled with a white chyle : but they do not always convey a fluid of this colour ; for, even in a dog, if opened long after a meal, they are found distended with a liquor that is transparent and colourless like the lymph ; and in birds the chyle is never found white, but always transparent : these vessels, therefore, might, with as much propriety, be called the *lymphatics of the intestines*.

The lymphatic vessels are small pellucid tubes that have now been discovered in most parts of the human body : the fluid they contain is generally as colourless

less as water; a circumstance which procured them at first the name of *ductus aquosi*, and afterwards that of *vasa lymphatica*. The course of the lymph, like that of the chyle, is from the extreme parts of the body towards the centre, and many of the lymphatic vessels lie close to the large blood-vessels. If therefore a ligature be thrown round the large blood-vessels of the extremities of a living animal, or of one just dead, that ligature, by embracing the lymphatics, will stop the course of the lymph, which by distending the vessels will make them visible below the ligature.

All the lacteals, and most of the lymphatic vessels, open into the thoracic duct, which lies upon the spine, and runs up towards the neck of the animal, where it commonly opens into the angle between the internal jugular and subclavian veins of the left side; and thus both the chyle and lymph are mixed with the blood. If therefore a ligature be thrown round the thoracic duct immediately after killing an animal, not only the lacteal, but also the lymphatic vessels, in the abdomen and lower extremities, become distended with their natural fluids; the course of those fluids being stopped by the ligature.

The lacteals, the lymphatics, and the thoracic duct, all agree in having their coats thinner and more pellucid than those of the blood-vessels. But although their coats are so thin, they are very strong, as we daily see on injecting them with mercury, since they resist a column of that fluid, whose weight would make it burst through blood-vessels, the coats of which are many times thicker than those of the lymphatic system.

The thinness of the coats prevents our dividing them from one another, and thereby ascertaining their number as we do those of the blood-vessels. But as the blood-vessels have a dense internal coat to prevent transudation, we have reason to believe the lymphatics have the same. And as the blood-vessels have a muscular coat,

coat, which assists in the circulation; so may the lymphatics. This is rendered probable from what Dr Haller says of his having found them irritable in his experiments, and also from what is observed on seeing them in living animals distended with their lymph, in which case they appear of a considerable size; but upon emptying them of their contents, they contract so much as not to be easily distinguished. This experiment, Mr Hewson informs us, he frequently made in the trunk of the lacteals in a goose, and on the lymphatic vessels on its neck; both of which, when distended with their natural fluids, are as large as a crow-quill; but, upon emptying them in the living animal, he has seen them contract so much that it was with the greatest difficulty he could distinguish them from the fibres.

The coats of lymphatic vessels have, in common with all other parts of the body, arteries, and veins, for their nourishment. This is rendered probable by their being susceptible of inflammation; for they are frequently found in the form of a cord, painful to the touch, and extending from an ulcer to the next lymphatic gland. These painful swellings of lymphatic vessels likewise show that their coats have sensibility, and therefore that they have nerves as well as arteries and veins. Besides, we can clearly trace in different parts of the body blood-vessels running along their surfaces.

The lymphatic system in most animals, but particularly in man and quadrupeds, is full of valves. These valves have been painted by the celebrated Nuck, Ruysh, and others, and are much more frequent than in the common veins, and thence these lymphatics have sometimes been distinguished by the name of *valvular lymphatic vessels*. Those valves are generally two in number, are of a semilunar shape, and the one is sometimes much larger than the other. In most parts

parts of the body these valves are so numerous, that there are three or four pair in an inch of space, but sometimes there is no more than one pair, and sometimes several inches of a lymphatic appear without a valve. They are less numerous in the thoracic duct than in the branches of the system; thence it might be supposed, that in proportion as we go from the trunk to the branches, we should find them thicker set: but this is not always true, for Mr Hewson observed them more numerous in the lymphatic vessels of the thigh than on those of the leg. When the vessels are distended with lymph, they appear larger on that side of the valves next the heart; which sometimes gives a lymphatic vessel an appearance of being made of a chain of vesicles: as such they are represented by some authors; but it is an appearance that very seldom occurs in the human body. In quadrupeds, however, this appearance is very remarkable. Wherever a lymphatic vessels enters the thoracic duct or a red vein, we find either one or two valves which prevent the return of the lymph, or hinder the blood from getting into the lymphatic.

Lastly, the lymphatic system, in different parts of its course, has the glands called *conglobate* or *lymphatic*. These glands are so placed, that the vessels come in on one side, and pass out on the other, in their way to the thoracic duct. They are commonly of an oval, though sometimes of a round shape, and frequently somewhat flattened, and of various sizes; some being no larger than a millet seed, while others are almost an inch in diameter. They vary in colour in different parts of the body, and at different times of life. In young people they are generally of a reddish or brown colour; but become paler with age: They have a shining external surface, which is owing to a smooth dense coat that covers them. Like other glands, they have arteries, veins, and nerves, which enter into their composition: but with respect to the rest

rest of their structure, anatomists are much divided in opinion ; some endeavouring to prove that they are formed of cells, while others of equal credit consider them as a collection of vessels. Before the discovery of the lymphatic vessels in birds, fish, and turtle, some anatomists have considered these glands as so essentially necessary to the lymphatic system, that they have generally set about discovering the vessels by first looking for those glands : and wherever they found glands, they pronounced that there must be vessels ; and when no glands could be seen, they thought it as certain a proof of their being no vessels. But that they are wanting in some animals, is now generally known.

### Section II. *A particular Description of the Absorbent System in the Human Body.*

THE absorbent system, besides the glands, is divided into three parts, viz. The lacteals, the lymphatic vessels, and the thoracic duct. The lacteals belong to the intestinal tube ; the lymphatics, to all the other parts of the body ; and the thoracic duct is the common trunk which receives both the lacteals and the lymphatics. We shall give a particular description of these, chiefly from Hewson, Mascagni, and Cruikshank, by whose attention this part of anatomy has been so greatly illustrated.

#### § 1. *Lymphatic Vessels of the Lower Extremities.*

THESE may be divided into two sets, viz. a superficial, and a deep-seated.

The superficial set of lymphatics consists of numerous vessels that lie between the skin and the muscles, and belong to the surface of the body or the skin, and to the cellular membrane which lies immediately under it. Of these there are numerous large branches that

that can be readily enough discovered in the limbs of dropsical subjects. Many of these run upon the top of the foot; one of them is represented Plate XIII. fig. i. (10); others are generally to be found just under the inner ankle; pipes have been introduced into two of them, whereby they have been filled the whole length of the lower extremity, as is seen in this figure.

The greater number of superficial lymphatics accompany the vena saphena major. They can be first traced from the toes; and there they run somewhat like the arteries and veins. A plexus, consisting of several vessels, runs over the top of the foot with the saphena to the inner ankle; and from thence upwards to the inner side of the knee. Here they are joined by another set which arises from the sole, and passes up on the inner and back part of the leg. A third set arises from the outer-side of the foot, and runs by the outer ankle. Upon the outer part of the leg, these split into two divisions; one of which crosses obliquely over the fore-part of the leg to the lymphatics, at the inner side of the knee, while the remaining part accompanies the vena saphena minor, and runs to the glandulæ popliteæ. From the inside of the knee a plexus runs up, consisting of from a dozen to twenty trunks, which pass afterwards on the anterior and inner side of the thigh to the inguinal glands. In their passage they receive branches from the outer and back parts of the thigh; but these are few in number when compared with the rest.

The lymphatic glands of the groin are six, seven, eight, or upwards; they vary much in number: of these, some lie in the very angle between the thigh and the abdomen, and others lie a few inches down on the fore-part of the thigh. The lymphatic vessels, above described, enter the lowermost of these glands, which in the subject of this figure, are four in number, viz. (15 15, 16 16. One or more of these branches, however, frequently avoids the glands, as at (17); which afterwards bends

bend over at (18) to the gland (19); from which go vessels to the other lymphatic glands (20, 20) that lie in the angle between the thigh and the abdomen, and sometimes a few enter no glands till they reach those on the inside of Poupart's ligament.

Into the inguinal glands also numerous lymphatics pass from the superficial parts of the abdomen and pelvis. See Mascagni, Tab. iii.

It is into these upper glands alone that the lymphatic vessels of the genitals enter, so that the venereal bubo which arises in consequence of an absorption of matter from these organs, is always seated in those upper glands, and the lower glands (15 15, 16, 16) are never affected, except by the regurgitation of the matter, or from their vicinity to the glands first diseased, which very seldom happens. And, as it is the upper glands that are affected by the absorption of matter from the genitals, so it is the lower which are commonly first affected from the absorption of the acrid matter of an ulcer, diseased joint, or carious bone, (in the parts below these glands); a circumstance that may assist us in the diagnosis of those two kinds of buboes: Remembering, however, that this rule may be liable to an exception from one or more of the lymphatic vessels passing the lower glands, and only entering the upper, as is seen at (17) in the same figure.

In the penis three principal vessels commonly take their origin from the prepuce. These soon unite, and afterwards separate upon the middle of the dorsum penis into two parts; one of which goes to the inguinal glands on the right side, the other to those on the left, and which are situated at the upper and anterior part of the groin.

The deep seated lymphatics arise from the glands and body of the penis, and accompany the arteries into the lower part of the pelvis. Hence if venereal matter be absorbed by these vessels the constitution may be affected without our being aware of it.

The

The lymphatic vessels of the testicle are numerous and very large for the size of this organ. They arise from its coats, from the body of the testicle, and from the epididymis; and after running along the spermatic cord, terminate in the lumbar glands. In their course they have few communications with each other.

The lymphatics of the scrotum, which are also numerous, go chiefly to the glands of the groin, though some pass along with those of the testicle to the lumbar glands.

The lymphatic vessels of the penis and scrotum having joined those of the thigh, a network is formed, which enters the abdomen under the edge of the tendon of the external oblique muscle, called *Poupart's ligament*: one of these vessels is seen in Tab. XIV. (26). This plexus on the inside of Poupart's ligament consists of many branches; some of which embrace the iliac artery, of which one is seen in (27) *ibid.* but the greatest number of them pass up on the inside of the artery, as is seen at (21, 22) Tab. XIII. fig. i. and at (27) Tab. XIV.

The superficial lymphatics of the inferior extremity are the trunks of those vessels which absorb from the skin and the cellular membrane immediately under it; but they likewise communicate with the deep seated absorbents: and the same thing is to be observed with respect to the lymphatics on all the other parts of the surface of the body.

Upon these vessels, from the foot to the groin, there is commonly not one lymphatic gland, besides those of the ham. But this rule has likewise some exceptions: for, even at the lower part of the leg, there is a very small one in the subject from which this plate was taken, as represented at (13), Tab. XIII. fig. i. and in another subject Mr Hewson saw a small lymphatic gland near (14); from which it may be concluded, that the lymphatic glands, even in the human body, are in number and situation a little different in different subjects.

Besides

Besides these superficial lymphatic vessels which lie above all the muscles, or in the cellular membrane under the skin, there is a set deeper seated that lie amongst the muscles, and accompany the arteries, and like the veins, one lies on each side. Of these the principal trunks can be discovered by cutting down to the posterior tibial artery, near the inner ankle. By introducing pipes into these parts, they may be injected; as has been done in several subjects, one of which is represented Tab. XIII. fig. ii.

From the inner ankle at (13) *ibid.* these vessels pass up along with the posterior tibial artery, being hid amongst the muscles on the back part of the tibia. About the middle of the leg they sometimes, though rarely, enter a small gland at (15), which has been supposed to exist more frequently than it really does. Afterwards they are seen in the back part of the ham, still lying close to the artery, and in the ham they pass through two or three glands which are commonly found there, viz. (18, 19, 20). But after they have passed these glands, they commonly divide into two or three branches, which accompany the crural artery, and pass with it through the perforation in the triceps muscle. Besides these, similar, though smaller, lymphatics accompany the anterior tibial and the fibular artery; these run likewise to the glands of the ham. The muscle is divided in the preparation from which this figure was taken, in order to give a better view of the lymphatics; and the cut ends of the muscle appear at (6, 6) though not very distinctly, from their being shrunk by drying. The lymphatic vessels having perforated the triceps, pass up with the artery, as is seen at (22, 23) and sometimes enter a gland (24), which is deeper seated than those which appear in the groin: from this gland they pass into the superficial glands, represented at (15 15, 16, 16) where the lymph of the deep seated and of the superficial lymphatics is mixed, and is conveyed into the body by the vessels seen just above in the same figure. At this

part likewise the lymph from the penis and scrotum is mixed with that brought by the two sets of lymphatics from the lower extremities; and the whole enters the abdomen, under Paupert's ligament, by the plexus of vessels represented fig. i. at (21), and a part of it at Tab. XIV. (27).

Tab. XIII. fig. i. represents the lower extremity, with its more superficial lymphatic vessels, N (1) is the spine of the os ilium, (2) the os pubis, (3) the iliac artery, (4) the knee. The other references have been explained in the course of the description.

Fig. ii. gives a back view of the lower extremity, dissected so as to show the deeper seated lymphatic vessels which accompany the arteries. (1) The os pubis. (2) The tuberosity of the ischium. (3) That part of the os ilium which was articulated with the os sacrum. (4) The extremity of the iliac artery appearing above the groin. (5) The knee. (6, 6) The two cut surfaces of the triceps muscle, which was divided to show the lymphatic vessels that pass through its perforation along with the crural artery. (7) The edge of the musculus gracilis. (8) The gastrocnemius and soleus, much shrunk by being dried, and by the soleus being separated from the tibia to expose the vessels. (9) The heel. (10) The sole of the foot. (11) The superficial lymphatic vessels passing over the knee, to get to the thigh. (12) The posterior tibial artery. (13) A lymphatic vessel accompanying the posterior tibial artery. (14) The same vessel crossing the artery. (15) A small lymphatic gland, through which this deep-seated lymphatic vessel passes. (16) The lymphatic vessel passing under a small part of the soleus, which is left attached to the bone, the rest being removed. (17) The lymphatic vessel crossing the popliteal artery. (18), (19), (20) Lymphatic glands in the ham, through which the lymphatic vessel passes. (21) The lymphatic vessel passing with the crural artery through the perforation of the triceps muscle, (22) The lymphatic vessel, after it has passed the per-

foration of the triceps, dividing into branches which embrace the artery (2.). (24) A lymphatic gland belonging to the deep-seated lymphatic vessel. At this place those vessels pass to the fore-part of the groin, where they communicate with the superficial lymphatic vessels. (25) A part of the superficial lymphatic vessels appearing on the brim of the pelvis.

2. *Absorbent Vessels of the Trunk.*

THE lymphatics of the lower extremities having now reached the trunk of the body, and having passed under Poupart's ligament, appear upon the sides of the ossa pubis near the pelvis at (27, 27) Tab. XIV. A part of them passes up along with the iliac artery upon the brim of the pelvis; and another part dips down into the cavity of the pelvis, and joins the internal iliac artery near the sciatic notch. At this place they are joined by the lymphatics from the contents of the pelvis, particularly from the bladder and the vesiculae seminales in the male, and from the uterus in the female; and there are likewise several branches which pass thro' the sciatic notch from the neighbourhood of the glutei muscles. The lymphatic vessels of the uterus, like its blood-vessels, are much enlarged, and therefore easily distinguished, in the pregnant state of that organ. They are in two sets; one runs along with the hypogastric arteries and veins; the other with the spermatic vessels. The lymphatics of the external parts of generation in the female go partly to the inguinal glands of each side, and partly through the rings of the external oblique muscles to terminate in the glands of the loins or pelvis. At this part, where so many lymphatics vessels join, there is commonly one or two glands.

Besides those lymphatic vessels which dip down into the cavity of the pelvis on the inside of the external iliac artery at (27, 27), there are others which keep on the outside of that artery upon the psoas muscle, some

of

of which are seen on the left side in the same plate at (28.) Of these, one part passes up to the loins at (32), and goes under the aorta in different branches, getting from the left side to the right, and joining the thoracic duct. Another part passes under the iliac arteries, and appears upon the os sacrum at (30), making a beautiful network, joining the lymphatics of the right side, and passing under the iliac artery, to form the network (31) upon the upper part of the right psoas muscle. In different parts of this course from Poupart's ligament to the loins, and also in the loins themselves, there are, in most subjects, many lymphatic glands; none of which were filled in the subject from which this plate was made.

The lymphatic vessels of the right side, joined by some from the left, having now reached the right lumbar region, appear there in the form of a plexus of large vessels, and pass through several glands, which occupied the spaces (33, 33, 33), but not being injected in the subject are not represented. At this part likewise they receive large branches, under the aorta, from the plexus on the left side of the loins, as is mentioned before; and having at last got up as high as the second or more frequently the third lumbar vertebra, they all join, and form a single trunk called the *thoracic duct*, which is seen at (36). At this part they are likewise joined by the lacteals, which shall be next described.

The lacteal vessels, so called from their commonly conveying a fluid that is of the colour of milk, are found in two sets which communicate with each other; the internal begin from the inner surface of the intestines, where each lacteal is at first formed upon the surface of the villi by numerous small radiated branches, with orifices destined to imbibe the nutritious fluid or chyle: From the cavity of the intestines these vessels pass obliquely through their coats, uniting as they go, so as to form larger branches. They follow the course of the arteries and veins, and are double their num-

ber; one being situated on each side. These branches run on the outside of the gut to get to that part which is next the mesentery; and, whilst they are yet upon the gut, they are sometimes of a size sufficient to admit a small pipe, so that they have been frequently injected with mercury in the human subject. And in man as well as in different animals the external set appear between the peritoneal and muscular coat, and commonly run for a considerable way in the same direction with the intestine.

From the intestines they run along the mesentery and mesocolon, towards the spine; passing thro' the lacteals in their way to the conglobate or mesenteric glands. These glands divide the lacteals into two regions: from the intestines to the glands these vessels are called *lactea primi generis*; and from the glands to the thoracic duct, *lactea secundi generis*. (See Sheldon on the Absorbent System).

The lacteals of the *jejunum* are larger and more numerous than those of the *ilium*. Those of the small intestines, as they run upon the mesentery, commonly accompany the superior mesenteric artery, and unite, as they proceed into larger branches; so that by the time they arrive at the root of the mesentery, they are of a considerable size, as may be seen at (34). From the mesenteric artery they descend by the sides of the aorta, and open at last into the thoracic duct (36): the lacteals, or rather the lymphatics of the large intestines, run somewhat differently. Those from the *cæcum*, and from the right part and great arch of the colon, join the trunks of the lacteals of the small intestines about the root of the mesentery, whilst those from the rest of the colon terminate in the lumbar glands, or lower part of the thoracic duct, accompany the inferior mesenteric artery, and communicate with the large lymphatic vessels near its root.

Into the thoracic duct at (36), likewise enters the lymph of the other abdominal viscera. This is brought by a number of vessels, which in all the viscera run in

a superficial and deep set; a plexus of these may be traced from each kidney, lying principally behind the emulgent artery, and opening into large lymphatic vessels near the aorta. The lymphatics of the kidney are seldom seen in the sound state of that viscus; but when it is enlarged or ulcerated, they are sometimes observed distinctly: they run from its outer towards its inner edge, and immediately afterwards pass thro' the glands of the loins. The lymphatics of the glandulæ renales, or renal capsulæ, likewise terminate in the renal plexus.

The lymphatic vessels of the spleen pass from the concave side of that viscus, along with the splenic artery in the sinuosity of the pancreas, by the lymphatic vessels of which they are joined. The deep seated lymphatics of the spleen are very considerable, and can be readily seen at its concave edge, but those on its surface are small and few in number in quadrupeds; however, as in the bullock, they are remarkably numerous and large.

To the stomach belong two sets of lymphatic vessels, the one running upon its lesser, and the other upon its greater curvature. Of these, the former accompanies the coronary artery, and passes through some lymphatic glands that lie by its sides. The other set passes from the great curvature of the stomach, partly to the left and partly to the right side. Those on the left side receive the lymphatics of the left half of the great omentum, and run with the lymphatics of the spleen and pancreas to the thoracic duct. Those on the right side, receive the lymphatics from the right half of the great omentum, and pass through some lymphatic glands that lie close to the arteria gastrica dextra. Descending by the pylorus, they meet the plexus that accompanied the coronary artery; and near the lesser curvature of the duodenum, form a considerable network. Into this not only the lymphatics from the spleen enter, but likewise those from the gall-bladder, together with the deep seated lymphatics of the liver. Several branches proceed from this network; some running under the duodenum, and

others over it ; which all open into the thoracic duct, near the termination of the large trunk of the lacteals, as seen at (36.) The thoracic duct therefore is the common trunk which receives the absorbent vessels of the lower extremities, the lacteals, and the lymphatics of the abdominal viscera.

The lymphatics of the liver, like those of the other viscera, are in two sets ; one which lies upon the surface of the organ, and the other which accompanies the large blood-vessels in its centre. Here these two sets are found to communicate with each other very freely ; so that, by injecting mercury into the lymphatic vessels which lie upon its convex surface, we may fill those which accompany the pori bilarii and vena portarum in its centre. Most of the lymphatic vessels which lie upon the convex surface of the liver, run towards its falciform ligament, and pass through the diaphragm into glands which are situated on the anterior part of the pericardium. But others of them run towards the lateral ligaments of the liver, where they pass also through the diaphragm, and afterwards run on its upper surface to join those from the ligamentum latum. This is the common course of the absorbents on the convex side of the liver ; but there is great variety.

From the glands above mentioned, a large trunk runs up behind the sternum, between the laminae of the anterior mediastinum, and commonly joins the thoracic duct near its termination. Sometimes, however, instead of finding one trunk behind the sternum, we meet with two or more in each side of the thorax accompanying the internal mammary-vessels ; those of the left side ending in the thoracic duct ; those in the right going into the lymphatic trunk in that side of the neck.

The lymphatics on the concave surface run towards the portæ, where they join those which come from the centre of the liver along with its large blood-vessels. After they get from the liver, they are found to be very numerous. They pass into glands on the vena portarum ; and

and afterwards end in the thoracic duct, near the root of the superior mesenteric artery. It is remarkable of those lymphatic vessels which run upon the surface of the liver, that their valves can readily be made to give way, so that they may be injected from their trunks to their branches, and to great minuteness.

It has been suggested by Dr Meckel, that the lymphatics of the stomach do not open into the thoracic duct like those of the other viscera, but only open into the sanguiferous veins of the stomach: but from repeated dissections of the human subject, Mr Hewson has been convinced of the contrary; and likewise from the analogy with other animals, particularly fish, whose lymphatic vessels either have no valves, or the valves readily give way, so that he has repeatedly pushed injections from the thoracic duct into the lymphatics of their stomachs, as he has also done into the lymphatics of the other viscera contained in the cavity of their abdomen.

The thoracic duct, which receives all the vessels that we have yet described, differs in its size in different subjects, but is always smaller in its middle than at its beginning, as is seen in the plate. Sometimes its lower part (36) is still larger in proportion than is there represented; and that enlargement has been called the *receptaculum chyli*, and is considerable in some quadrupeds, in turtle, and in fish: but many anatomists have denied that there is any part of the thoracic duct in the human subject that deserves the name of *receptaculum*, having never seen any thing like a pyriform bag, as it has been described, but merely an enlargement not unlike a varix, and that only in few subjects; for that commonly it appears only a little larger than at its middle. This lower extremity of the thoracic duct is formed by the union of two or three very large trunks of lymphatic vessels. The first and second are, and other parts already described, formed by the lymphatics of the inferior extremities; the third belongs chiefly to the lacteals. These large vessels unite so as to form the duct over the third vertebra lumborum, reckoning from above downwards.

Upon the second vertebra of the loins, the union of these vessels is sometimes twice or thrice as large in diameter as the duct is higher up; at other times little or no enlargement can be observed.

These large lymphatic trunks which form the thoracic duct are spread out upon the spine, those of the right side lying below the right crus diaphragmatis, and those of the left passing between the aorta and the spine; whilst the thoracic duct itself lies at first behind the aorta; but afterwards passes from that upwards, and a little to the right side, till it gets before the first vertebra of the loins. Here it is situated behind the right crus of the diaphragm, where it enlarges again; and sometimes forms a pyriform bag, which has been considered by authors as the beginning of the duct. From this part it passes upwards, being at first covered by the crus diaphragmatis, and afterwards appears at (38) in the thorax, upon the spine between the aorta and the vena azygos. In the thorax it receives some lymphatics from the intercostal spaces; a few of which are seen at (39), and afterwards it receives vessels from the lungs.

The superficial lymphatics of the lungs form a beautiful network, the larger branches running chiefly between the lobules, the smaller passing over them; and here, as well as on the liver, and other parts, there are numerous valves; the existence of which has by some been denied. From the surface they pass to the root of the lungs, and there they go through the bronchial glands. At this place they are joined by the deep-seated absorbents which creep along the branches of the trachea, and likewise on those of the pulmonary artery and vein. Having left the glands, the principal part of those from the left lung form a trunk which terminates in the thoracic duct behind the division of the trachea into its right and left branches. The rest of the absorbents of the left lobe pass through glands behind the arch of the aorta, and which are likewise common to those of the heart. They run at last into the thoracic duct near its termination in the red veins.

After

After leaving the bronchial glands, the absorbents of the right lung form three or four principal trunks; one of which commonly ascends on the forepart of the vena cava superior, and opens into the lymphatic trunk, that terminates in the veins of the right side of the neck. The rest of these trunks go into the thoracic duct at the root of the lungs; and near this place the absorbents of the right and left lungs communicate pretty freely together.

At the root of the lungs, where the large blood-vessels enter, are many glands called *bronchial*. They are generally of a blackish colour in the human subject, and have been suspected to secrete the mucus which is spit up from the trachea; but later anatomists having frequently distinctly filled them with mercury by injecting the lymphatic vessels of the lungs, think it evident that they are not mucous but lymphatic glands.

The absorbents of the heart, which have been known only by the latest anatomists, come from its superficial and deep parts. These afterwards form principal trunks which accompany the coronary arteries and veins, and like them the largest belong to the left ventricle. From the side of the right coronary artery an absorbent passes over the arch of the aorta to a gland commonly found behind the origin of the carotid arteries. The lymphatic accompanying the left coronary artery is formed of two principal branches; one of which runs up in the groove between the ventricles; and on the superior surface of the heart, the other runs in a correspondent groove on the under side of the heart: and having reached the space between the auricles and ventricles, turns round to join the former branch near the origin of its corresponding artery. Frequently a third branch comes in between the other two. The trunk runs next to a gland between the arch of the aorta and the under end of the trachea; and at this place, as was formerly mentioned, the glands are common to the absorbents both of the heart and lungs. The absorbent accompanying the right

right coronary artery passes into the trunk, which terminates in the right subclavian vein; while the other, accompanying the left artery, goes to the upper end of the thoracic duct.

The thoracic duct, after receiving the vessels before mentioned, passes behind the ascending aorta, and goes to the left side, terminating in the angle between the jugular and the subclavian vein. But, just before its termination, it generally goes higher up than the angle, and then bends down towards it; see Tab.XIV. n° 42, 43. Sometimes, though rarely, there are two thoracic ducts instead of one. Sometimes the duct splits near the upper part of the thorax; and the two branches, after spreading out from one another, commonly unite again at their termination in the angle between the jugular vein and subclavian veins.

To the preceding account, it may not be improper to add the description given of the *Lacteal Sac and Duct* by the late Dr Alexander Monro.

" The receptaculum chyli of Pecquet, or saccus lacteus of Van Horne, is a membranous somewhat pyriform bag, two-thirds of an inch long, one-third of an inch over in its largest part when collapsed; situated on the first vertebra of the loins to the right of the aorta, a little higher than the right emulgent artery, behind the right inferior muscle of the diaphragm: it is formed by the union of three tubes; one from under the aorta, the second from the interstice of the aorta and cava, the third from under the emulgents of the right side.

" The lacteal sac, becoming gradually smaller towards its upper part, is contracted into a slender membranous pipe, of about a line diameter, which is generally named the *thoracic duct*. This passes betwixt the muscular appendices or inferior muscles of the diaphragm, on the right of, and somewhat behind, the aorta: then, being lodged in the cellular substance behind the pleura, it mounts between the aorta and the vena azygos as far as the fifth vertebra of the thorax, where

where it is hid by the azygos, as this vein rises forwards to join the descending or superior cava; after which the duct passes obliquely over to the left side behind the œsophagus, aorta descendens, and the great curvature of the aorta, until it reaches the left carotid artery; behind which, on the left side of the œsophagus, it runs to the interstice of the first and second vertebræ of the thorax, where it begins to separate from the carotid, stretching farther towards the left internal jugular vein by a circular turn, whose convex part is uppermost. At the top of this arch it splits into two for a line and an half; the superior branch receiving into it a large lymphatic vessel from the cervical glands. This lymphatic appears, by blowing air and injecting liquors into it, to have few valves. When the two branches are again united, the duct continues its course towards the internal jugular vein, behind which it descends, and, immediately at the left side of the insertion of this vein, enters the superior posterior part of the left subclavian vein, whose internal membrane duplicated, forms a semilunar valve that is convex externally, and covers two-thirds of the orifice of the duct; immediately below this orifice, a cervical vein from the musculi scaleni enters the subclavian.

" The coats of the sac and duct are thin transparent membranes; from the inside of which, in the duct, small semilunar valves are produced, most commonly in pairs; which are so situated as to allow the passage of liquors upwards, but oppose their return in an opposite course. The number of these is generally ten or twelve.

" This is the most simple and common course, situation, and structure of the receptaculum chyli and thoracic duct; but having had occasion to observe a variety in these parts, of different subjects, I shall set down the most remarkable of them.

" The sac is sometimes situated lower down than in the former description; is not always of the same dimensions;

mensions; is not composed of the same number of ducts; and frequently appears to consist of several small cells or ducts, instead of being one simple cavity.

"The diameter of the duct is various in most bodies, and is seldom uniform in the same subject; but frequently sudden enlargements or saeculi of it are observable.—The divisions which authors mention of this duct are very uncertain. I have seen it divided into two, whereof one branch climbed over the forepart of the aorta at the eighth vertebra of the thorax, and at the fifth slipped behind that artery, to join the other branch which continued in the ordinary course.—The precise vertebra, where it begins to turn to the left side, is also uncertain.—Frequently it does not split at its superior arch; in which case a large sac is found near its aperture into the subclavian vein.—Generally it has but one orifice; though I have seen two in one body, and three in another: Nay, sometimes it divides into two, under the curvature of the great artery; one goes to the right, another to the left subclavian vein; and I have found this duct discharging itself entirely into the right subclavian.—The lymphatic vessel which enters its superior arch, is often sent from the thyroid gland.

"Whether is not the situation of the receptaculum chyli so much nearer the muscular appendices of the diaphragm in men than in brutes, designed to supply the disadvantageous course the chyle must otherwise have in our erect posture?

"Does not the descent of the end of the duct to the subclavian vein, and the opening of the lymphatic into the top of the arch, contribute to the ready admission of the chyle into that vein?"

In the description of the lymphatic vessels which lie near the trunk of the body, only a few glands have been mentioned; and in the figure where those vessels are exhibited no glands are represented. For the lymphatic glands

glands not being constant either in number or situation, the describing them particularly in any one subject appeared less necessary, since we cannot be sure of finding them exactly the same in any other. It may, however, be necessary to mention where they are commonly seen.

The mesentery of the human subject is well known to contain a considerable number of them, from 100 to 150 or upwards; they are likewise found in the mesocolon, where the lymphatics of the large intestines pass through them; but here they are both smaller and less numerous than in the mesentery. The stomach has also several glands which belong to its lymphatic vessels, and lie near the arteria coronaria and the arteria gastrica dextra. There are likewise a few upon the omentum in some subjects; and there are also many by the sides of the pancreas, particularly near the lesser lobe of that viscus, close to the duodenum.

Besides these glands which belong to the intestinal tube, there are many more in the cavity of the abdomen, and a few in the cavity of the pelvis, which belong to the lymphatic vessels of the other organs.

There is commonly a pretty considerable gland seen just on the inside of the edge of the tendon of the external oblique muscle, called *Poupart's ligament*, on the outside of the iliac artery; and there are others near that artery, where it lies upon the psoas muscle. There are likewise commonly one or two near the internal iliac artery in the cavity of the pelvis; some on the surface of the os sacrum behind the rectum; and there is a considerable number generally met with by the sides, and upon the lumbar vertebræ.

Over the trunks of the blood-vessels of the spleen, liver, kidneys, and renal capsulæ, there are also lymphatic glands which belong to the lymphatic vessels of these organs. In the thorax, a few glands are found on the fore-part of the pericardium and upper surface of the diaphragm, and belong to the liver or dia-

phragm.

phragm. Others are situated between the laminæ of the anterior mediastinum.

There are likewise lymphatic glands sometimes observed by the sides of the thoracic duct, particularly about the middle of the thorax; which glands belong principally to the vessels of the lungs.

There are also many lymphatic glands (called *bronchial*) near the root of the lungs: these glands are placed upon the lymphatic vessels, just where they quit the lungs. But no lymphatic glands have yet been observed in the substance of the lungs; and the tubercles, which some suspect to be obstructed lymphatic glands, seem to have a different origin. There are likewise some glands seen on the lymphatic vessels which lie near the subclavian veins at the upper part of the thorax, and which belong to the lungs.

Besides these there are some lymphatic glands upon the aorta near the œsophagus, and there are also others occasionally met with in the intercostal spaces, and there are generally two or three contiguous to the thoracic duct at the lower part of the neck and upper part of the thorax, near the termination of that duct in the angle between the left jugular and the left subclavian vein; and a few are found over the internal mammary vessels where the absorbents of the liver pass up within the thorax.

### § 3. *Lymphatics of the Head and Neck.*

THE lymphatics of the head, like those in many other parts of the body, are in two sets; one belonging to the outer, the other to the inner, parts of the head. Those on the outside of the head accompany the blood vessels, and pass through glands in their way to the neck. Those accompanying the temporal artery go through small glands at the root of the zygomatic process, while the absorbents of the occiput pass through

through others behind the mastoid process of the temporal bone.

Several anatomists have seen an appearance of lymphatics both on the brain and its membranes; but none even of the latest authors have been certain about these. That the brain, however, has its absorbents, there can be little doubt; as is in some measure proved from the existence of lymphatics and glands, in or on the outside of the passages of the arteries and veins of the brain, from swellings in the lymphatic glands of the neck, arising from diseases of the brain, from the absorption of water which has sometimes happened in cases of hydrocephalus, and from several other circumstances.

From the superficial and deep parts of the head, the lymphatics pass through the glands situated near the carotid arteries and internal jugular veins, where they are joined by others, to be immediately described.

From the different parts of the face, the lymphatics chiefly accompany the branches and trunk of the facial artery. They come from the inner angle of the eye, from the nose, lips, and cheeks. Some of these pass through small glands on the outside of the buccinator muscle, while the principal branches go through larger glands on the outer and under side of the lower jaw, near the corresponding blood-vessels, and the inferior maxillary gland. Others run through the glands on the upper and under end of the parotid gland. The lymphatics of the inner side of the nose run principally with the internal maxillary artery, and pass through the glands behind the angle of the lower jaw, where they are joined by others from the inner part of the mouth. Deeper than this, and near the internal jugular vein, the lymphatics of the tongue, and parts about the os hyoides, pass through the glands which belong likewise to those of the deep parts of the head.

The glands which accompany the lower part of the artery

artery that runs upon the face, are sometimes swelled in consequence of absorption from the lips, and also from gum boils; and those which accompany the occipital artery, are frequently enlarged in consequence of absorption of matter from wounds of the scalp; from which facts we are led to trace the course of the lymph even in the living body. In quadrupeds those vessels may be distinctly seen, particularly in a dog or an ass, by passing a ligature round the large blood-vessels of their necks immediately after killing them. Mr Hewson made some experiments of this kind, with a view to determine whether the brain had lymphatic vessels; but he informs us he was never able to see any on that organ; neither when he tied up the lymphatics on the necks of those animals, nor when he dissected the human brain, with a view to discover those vessels, although he particularly sought for them in the plexus choroides, where they have been suspected to be seen, and near the glandular pituitaria: but that although lymphatic vessels have not been demonstrated in the brain, it is probable from analogy that this organ is not destitute of them.

The lymphatics already described from the different parts which belong to the head, accompany the external and internal jugular veins, though chiefly the latter, where they form a large and beautiful plexus, passing through numerous glands in the whole length of the neck. At the under end of the neck they join the lymphatics of the superior extremities, and then form a common trunk to be afterwards mentioned.

The glandula thyroidea has many lymphatic vessels, which can be inflated by blowing air into the cells of the gland: these vessels pass on each side of the trachea, one part going into the trunk, which terminates in the right subclavian and jugular, and the other joining the thoracic duct upon the left side near its termination.

In Tab. XIV. which exhibits the trunk so prepared as to show the lymphatics and the thoracic duct, (1) is

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TAB. XIII.

FIG. I.

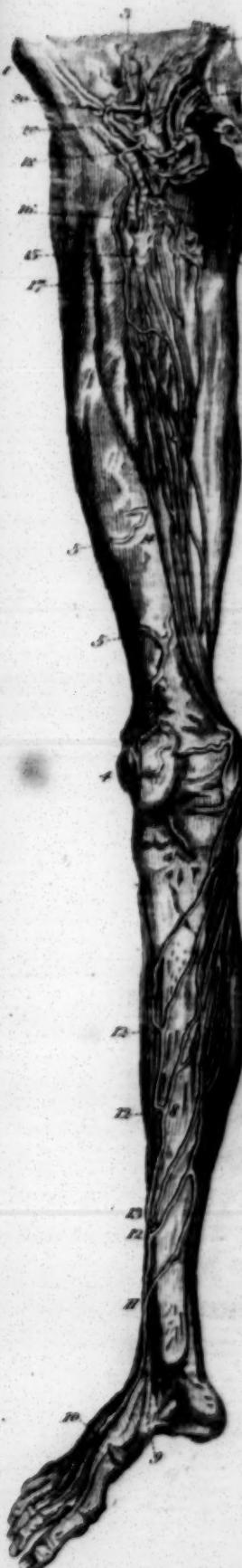


FIG. II.



FIG. IV.

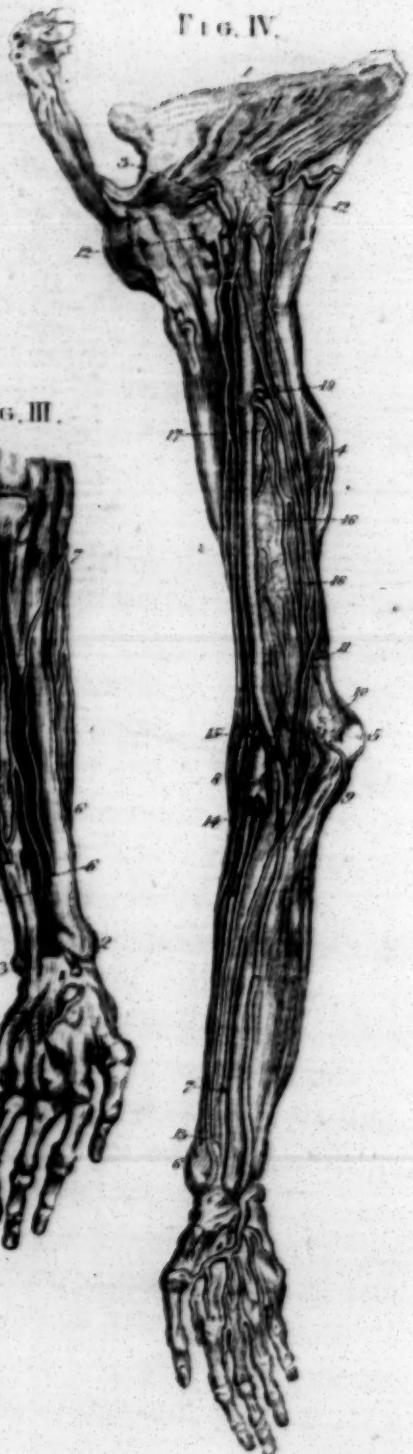
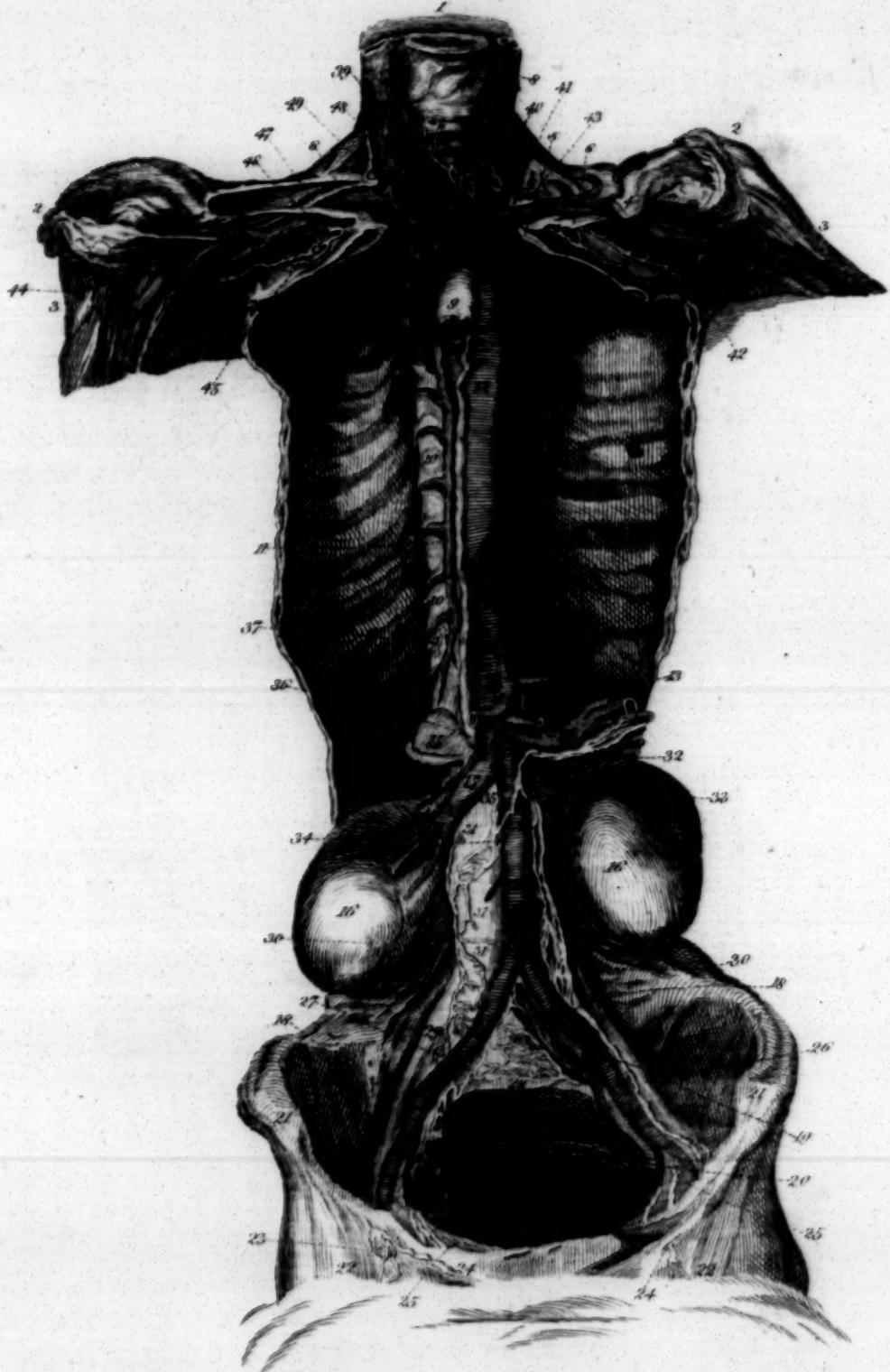


FIG. III.

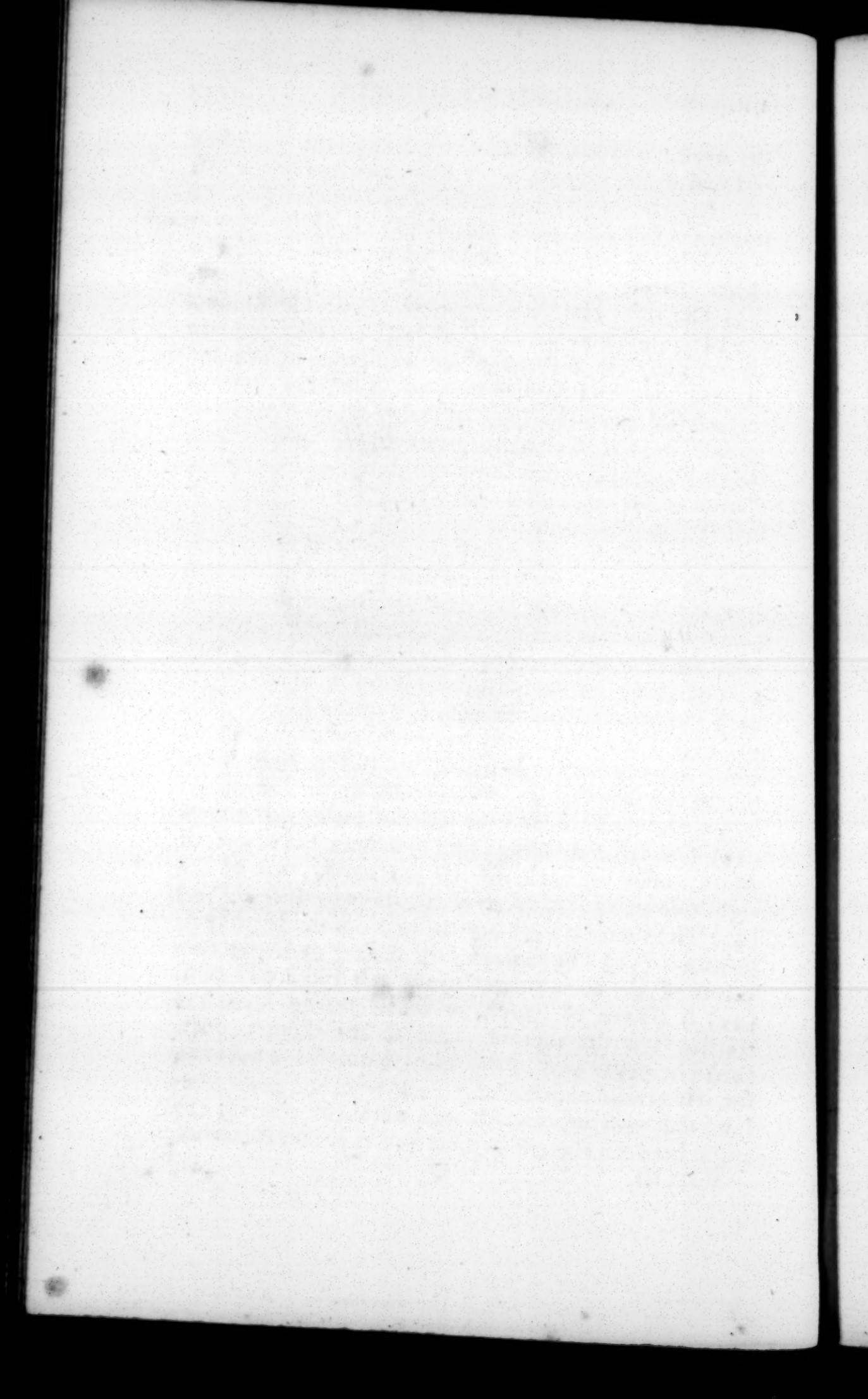


D. Lizaro Sculp<sup>r</sup>

T A B. XIV.



D. Lizaro Sculp<sup>t</sup>.



the neck. (2) The shoulder. (3) The arm. (4) The out end of the clavicle. (5) The extremity of the first rib. (6) The subclavian muscle. (7) The rib. (8) The trachea. (9) The aorta ascendens. (10) The spine. (11) Vena azygos. (12) The aorta descendens. (13) The cæliac artery. (14) The superior mesenteric artery. (15) The right crus diaphragmatis. (16) The kidney. (17) The right emulgent artery. (18) The common iliac artery. (19) The division of the common iliac into the external and internal iliac arteries. (20) The cavity of the pelvis. (21) The spine of the os ilium. (22) The groin. (23) A lymphatic gland in the groin, into which lymphatic vessels from the lower extremity are seen to enter. (26) The psoas muscle with lymphatic vessels lying upon its inside. (27) A plexus of lymphatics, which having passed over the brim of the pelvis at (25), having entered the cavity of the pelvis, and received the lymphatic vessels belonging to the viscera contained in that cavity, next ascends, and passes behind the iliac artery to (29). (29) The right psoas, with a large plexus of lymphatics lying on its intide. (30, 30,) The plexus lying on each side of the spine. (31, 31, 31,) Spaces occupied by the lymphatic glands; which are not here represented, not having been injected in the subject. (32) The trunk of the lacteals lying on the under side of the superior mesenteric artery. (33) The same dividing into two branches; one of which passes on each side of the aorta, that of the right side being seen to enter the thoracic duct at (34.) (34) The thoracic duct beginning from the large lymphatics. (38) The thoracic duct passing under the curvature of the aorta to get to the left subclavian vein. (39) A plexus of lymphatic vessels passing upon the trachea from the thyroid gland to the thoracic duct. (40) The upper part of the thoracic duct lying between the left carotid and the left jugular vein, and passing behind that vein downwards and outwards towards the angle between the left jugular and the left subclavian.

(41) The extremity of the angle between the left jugular vein. (46) That network of veins under the clavian vein, and under the pectoral muscle being removed.

N. B. The other Nos. are given in the descriptions.

#### §4. Lymphatics of the Arm.

LIKE the leg, each arm has two sets of lymphatic vessels. One set, which lies beneath the integuments, belongs to the skin; the other, which accom-

panies the large arteries, and is connected with them.

The superficial set of lymphatic vessels of the arm may be discovered in the following manner:—By a careful dissection of the skin and subcutaneous tissue of the arm. They arise first from the skin of the hand, wrist, and palm of the hand, and from the skin of the forearm. They go to the fore-arm, from the outer and inner sides, running a little further, and then uniting, and forming a plexus which surrounds the bone of the fore-arm. Having got about half way up the arm, they run near the basilic vein, and, passing over the condyle of the humerus, enter the axilla. But the lymphatics on the outer side of the arm, and on the thumb appear to pass thro' the skin, and enter the axilla. The rest of the lymphatics of the arm, which are found in the skin, and in the subcutaneous tissue, pass between the deltoid and trapezius, and then go thro' glands at the

## LYMPHATIC VESSELS. Part VI.

y of the thoracic duct entering the left jugular and the left subclavian network passing under the right sub-clavicle, and under the subclavian muscle, the clavicle.

er N<sup>o</sup>. are explained in the course of

### *Lymphatics of the Upper Extremities.*

Each arm has two sets of lymphatic vessels, which lies immediately under the skin, and the cellular membrane, and belongs to the skin and the cellular membrane; the other accompanies the arteries, and belongs to the parts deeper

set of lymphatic vessels are numerous, and are frequently observed in emaciated dropsical subjects, one set lying on the fore and back part of the arm, the other from the fore-part of the fingers, and run somewhat like the veins. They meet in the fore-arm, where they meet with others from the hand and fingers, and then run further, they receive many branches from the hand and fingers, and then form a network which surrounds the greater part of the arm. When they get above the elbow, most of them join the brachial vein, and commonly pass through the axillary glands, a little above the internal angle of the humerus, and over the brachial artery; and then they pass on that side of the arm next the body, till they reach the shoulder, where they join the rest of the lymphatics accompanying the artery, and are but few in number: they pass through the deltoid and pectoral muscles, and end at the inside of the clavicle. Of the deep-

## Chap. VII. ABSORBENT VESSELS

deep-seated lymphatics of the arm to company each artery, in the same manner: Having reached the upper end go through the axillary glands, whereby the lymphatics from the mammae, thorax, and also by those from the these glands larger branches run upwards and form a trunk, which receives the head and neck already described.

fig. iii. some of the lymphatics are seen in the back part of the fore arm at (6, 6) passing on its outside, and twisting to the head of the radius, as at (7). In presentation, there is a vessel which passes fide, under the inner condyle of the ulna and sends a branch amongst the muscles, perforates the interosseous ligament between the radius and ulna to the fore-part, and joins a deep-seated one that had accompanied the artery.

In this figure, which exhibits a back of the arm and hand, (1) Is the hand. (2) The lower extremity of the radius. (3) The lower extremity of the ulna. (4) The muscles on the back of the arm turned aside to exhibit a deep-seated vessel which perforates the interosseous ligament of the fore-part.

(5) The olecranon.—The hand has been already referred to.

In Tab. XIII. fig. iv. the lymphatics of the fore-part of the upper extremity are shown, the superficial branches which passed on the outer side of the fore-arm appearing now on the inner side and ascending under the skin that covers the triceps, longus and the biceps, they enter the axilla at (12, 12), whilst that vessel which descends on the inside of the back of the fore-arm, under the inner condyle, appears on the fore-part above the condyle enters a gland (13).

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up on the inside of the arm, communicating with a lymphatic from the fore-part of the wrist, and passing to the axillary glands.

A superficial lymphatic is seen under the skin, on the fore part of this extremity just above the wrist; a pipe was introduced at (7), and the vessel thereby injected with mercury. Passing under the integuments over all the muscles, this vessel joins the lymphatic from the back-part of the fore-arm at (11), and there forms a plexus which passes under the integuments, on the inside of the arm, to the axillary glands at (12).

Besides these superficial lymphatics upon the upper extremity, others lie near the radial artery; one is injected from a pipe fixed at (13). This vessel accompanies the radial artery, and passes (14) first under the interosseous, and then under the ulnar artery, which in this subject runs over the muscles. Near the part where it passes under the interosseous artery, it receives the branch from the back of the fore arm. After passing under these arteries, this lymphatic appears on the inside of the brachial artery at (15), where it is deep-seated. Ascending close to that artery, and near the middle of the arm, it passes through the two glands (16, 16); after which it appears considerably enlarged, goes under one of the arteriæ anastomoticæ at (17, 18), and then ascends to the lymphatic glands in the axilla (19, 19).

In the above figure, which exhibits a fore-view of the upper extremity, (1) is the scapula, (2) the clavicle, (3) the extremity of the brachial artery, (4) the muscles lying on the inside of the arm, (5) the inner condyle of the os humeri, (6) the lower extremity of the radius. N.B. The subsequent Nos denoting the vessels have been explained in the description.

These vessels, however, as they here appear, although represented from a successful injection, are only a part of the larger lymphatic vessels of the arm; and there are some accompanying the ulnar and interosseous

interosseous arteries, although not here injected. They should moreover be considered as only trunks of the lymphatics; since it is probable, that every (even the smallest) part of this, as well as all other parts of the body, has some of these vessels adapted to absorption. That this is the case, seems to be proved by the experiments made with the variolous matter; for at what part soever of the arm that matter is inserted, the lymphatic vessels take it up and carry it into the body, as can be traced by its inflaming the conglobate glands through which these vessels pass.

In Tab. XIV. the termination of all these lymphatic vessels is exhibited. Two of the trunks of those of the left arm are seen at (42, 42). They pass under the clavicle, whose cut end is seen at (4); and under the subclavian vein. Here, having joined, they form the large trunk (43), which appears just above the left subclavian vein, and joins the extremity of the thoracic duct at its entrance into the angle between that vein and the jugular.

The thoracic duct is not only joined by this trunk of the lymphatics of the left arm, but also by the lymphatic vessels of the left side of the thyroid gland, and by the trunk of the lymphatics of the left side of the head and neck, and also by some from the lungs of the same side.

The lymphatic vessels of the right side are commonly seen to terminate in the angle between the jugular vein and the subclavian. When seen to enter the subclavian vein at any other part, it appears to be only an accidental variety.

These lymphatic vessels of the right side form four considerable trunks, which join near their termination. These trunks are, 1. One from the upper extremity, which appears at (47), lying above the clavicle between the subclavian artery and vein: This trunk is formed by the lymphatics (44), which come up with the brachial

thial artery, and the plexus (45), which likewise belongs to the arm, and passes under the subclavian vein. 2. The trunk of the lymphatic vessels of the right side of the head and neck, which passes down on the outside of the jugular vein, as is shown at (48). 3. A lymphatic from the thyroid gland. This vessel is seen at (49), passing under the right jugular vein to get to the others. 4. A trunk from the lungs of the right side: This trunk is distinctly traced under the subclavian vein to its termination, in common with the others, at the union of the jugular and subclavian veins.

### § 5 Of the Chyle.

THE chyle is a white juice extracted from the aliments, which is afterwards mixed with the blood. That its principal composition is of water and oil, seems evident, from the sweetness of its taste, from the whiteness of its colour, from its acescent and coagulable nature, and from its lightness by which it swims on the blood; in all which properties it very much resembles an emulsion. It is composed of a vegetable farina, with animal lymph and oil. It every where retains the properties of the volatile and oily aliments. It changes into milk with very little alteration. But afterwards it becomes more manifestly glutinous; since the pellucid serum it contains, either by exhaling the watery part, or by applying an intense heat, coagulates into a kind of jelly.

That the chyle is absorbed into the lacteal vessels, by the adhering villous coat, has been a long time known, by experiments of injecting tinctured liquors, which readily describe the same course; from the white liquor of the lacteals, let out from blood-vessels; and from the venous nature of them. But late experiments have taught us this in a much better manner. The chyle is absorbed by small openings in the extremity of

of each of the villi, by the same force which is common to all capillary tubes, and perhaps also by a living power in these tubes, by which it is taken up into the cavity of the absorbing duct at the time when the intestine is relaxed ; but the parts, by which the absorbing duct begins in the intestine, being pressed by the succeeding constriction of the muscular fibres in the peristaltic motion, urges the contents further on into the duct, which begins to appear within the second cellular stratum. But there is a two-fold stratum of these absorbing vessels, one anterior, the other posterior, as we observed before of the blood-vessels. From thence, uniting into a larger canal in the first cellular stratum, the absorbed liquor enters into the lacteal vessel, which, in general, follows the course of the arteries, and likewise accompanies their arches, but conjoined with others similar to it into a very obliquely angled net-work. Very many arise from the first part of the small intestines under the mesocolon ; some from the duodenum, and some from the large intestines themselves.

The lacteal vessels are furnished with valves in the very first cellular texture of the intestine, like those of the lymphatics, joined together by pairs, of a semilunar figure, which admit the chyle passing from the intestines, but prevent its return, and sustain its weight. Through this whole course, the chyle is urged on by the peristaltic motion of the intestines, as well as by the contractile force of the vessels themselves, which, even after death, is strong enough to propel the chyle ; to which add, the considerable pressure of the abdominal muscles, and other parts, determined by the valves.

But betwixt the plates of the mesentery, at the divisions of the vessels, are found an infinite number of small conglobate glandules. Some lacteal vessels are seen to pass these glands : most part enter them ; and, being divided and subdivided through their cellular fabric, compose the greatest part of the gland. And,

again, other lacteal vessels are produced out of every gland; and, being mutually joined among themselves, go off in little trunks, of which the ultimate and largest ones go out from the gland. In the same manner the chyle enters other glandules twice, thrice, or four times; nor does any lacteal vessel arrive at the thoracic duct without meeting some of these glandules, although it may pass by some without entering them. But that this is the true course of the chyle, by which it passes from the intestines to the mesenteric glands, appears from a ligature, by the vessel growing turgid betwixt the said ligature and the intestine; and from scirrhosities in the glands, by which they are rendered more conspicuous; and from the nature of the valves themselves hindering any return back to the intestines.

What alteration the chyle undergoes within the cellular fabric of these glands is not yet sufficiently known; but it appears, in general, that some thin liquor distils from the arteries in this part, serving to dilute the chyle, into which it is poured. For it is observed, that after the chyle has surmounted all the glands, it appears more watery; and thin liquors, injected through the arteries, pass out into the cellular fabric of the glands, and mix with the chyle. Lastly, that a kind of cream appears manifestly in the glandules of infants.

From the last glandules, which are collected together in the centre of the mesentery, the lacteal vessels go out very large, and few, to the number of four, five, or more, which ascend together with the mesenteric artery, and intermix with the lymphatic plexus, that ascends from all the lower parts of the body, creeps over the renal vein, and then goes along with that which takes its course behind the aorta from the lumbar glandules, and with the hepatics. Here the lymphatics take a variable course, but most frequently terminate in the receptacle of the chyle. In this the gelatinous lymph of the lower limbs, and of the abdominal viscera, mixes with the chyle, and dilutes its white colour; thus sometimes

times it appears filled with a pellucid or reddish humour, but frequently also with a white milk. The receptacle of the chyle must suffer a considerable alternate pressure from the diaphragm and aorta, by which the chyle is moved faster through it, in proportion as the light of the capacity of the receptacle is greater than that of the thoracic duct, into which it empties itself.

That the chyle comes from the intestines into this duct, is shown from injections, by which quicksilver may be driven from the first lacteal vessels to the thoracic duct; from ligatures made on the duct itself, or the red veins which receive it, and by which the first and second lacteal vessels swell; and from the manifest flux of the chyle into the thoracic duct, when the ligatures are removed.

It appears that the chyle flows through the thoracic duct into the blood; because, on tying the red veins, both the thoracic duct and lacteal vessels which are inserted into it swell up.

Haller has attributed the first cause of motion in the chyle, and of its absorption, especially to the attraction of the capillary vessels, which observes alternate pulses with the peristaltic contraction of the intestine. The attractive force fills the villosity; the peristaltic force empties the villosity, and moves the chyle farther forward. The rest of its motions seem to depend on the strength of the membrane of the lacteal vessel itself, which, even after the death of the animal, expels the chyle, so that the vessels become pellucid, which before were milky. The alternate compressing force of the diaphragm also is of some efficacy in this case, and the motion of the chyle through the thorax is somewhat accelerated by the conduit itself; which being pressed, moves the chyle so much the more quickly forward, as itself is larger than the thoracic duct.

The chyle, mixed with the blood, does not immediately change its nature, as we learn from the milk which is afterwards made of it; but after five or more hours

hours have passed from the meals, almost to the twelfth hour, during all which space a woman will afford milk after it has circulated near 80,000 times through the body, fermented with heat, and mixed with a variety of animal juices, it is at length so changed that a part of it is deposited into the cellular substance, under the denomination of fat: a part of it is again configured into the red globules; another part, that is, of a mucous or gelatinous nature, changes into serum; and the watery parts go off, in some measure, by urine, in some measure exhaled by perspiration; while a small part is retained in the habit to dilute the blood. Nor is it any thing uncommon for a pellucid lymphatic liquor to fill the lacteals, in a dying animal, instead of chyle; or for some of them to appear milky in one part of the mesentery, and limpid or pellucid in another; since, as to their fabric and use, they also agree to answer the end of lymphatics. There are not, therefore, two kinds of vessels from the intestines; one to carry the chyle only, and another peculiarly for the conveyance of lymph. After the digestion has been completed some time, the lacteal vessels absorb pellucid watery juices from the intestines, whence they appear themselves diaphanous; but the thoracic duct is more especially a lymphatic of the largest order, conveying all the lymph of the abdomen, lower extremities, and most parts of the body to the blood.

C H A P.

## C H A P. VIII.

*Of the PROPERTIES of the LYMPH, as observed by  
Mr Hewson \*, &c.*

**A**S the fluid contained in the lymphatic vessels resembles water in the circumstances of transparency and want of colour, thence their first discoverers denominated these vessels *ductus aquosi*, and seem to have concluded that the lymph was nothing but water.

This opinion some of the succeeding physiologists, particularly the learned Boerhaave, rendered more probable, by supposing that there were three series of arteries; the sanguiferous, the seriferous, and the lymphatic; and that those lymphatic vessels we are now describing, were only veins corresponding to the lymphatic arteries, to restore their lymph to the heart. Thence the lymph seems to have been concluded the thinnest part of our fluids; in which opinion physiologists were confirmed by Leeuwenhoeck's theory, that the globules of lymph were smaller than those of the serum, or of the red part of the blood.

The fluids that moisten the different cavities of the body, viz. that of the peritonæum, pleura, pericardium, &c. being suspected to be formed solely from the condensation of that steam which appears on opening an animal just killed, have thence been also considered as mere water by some anatomists and physiologists;

\* The publisher has here to acknowledge the very polite manner in which Mrs Hewson gave him liberty to make use of such of her husband's discoveries and observations on the Lymphatic System as might be useful to this Work.

gists; who were confirmed in this opinion by observing, that in dropsies, where a great quantity of fluid is let out from such cavities, it is commonly a mere water, seldom coagulating either when exposed to the air or to heat. And, agreeably to this opinion, these dropsies are said to be occasioned by an increased secretion, or an impeded absorption; which supposes that the fluids, naturally moistening these cavities, are the same as those let out from them in dropsical cases.

But notwithstanding the plausibility of all the arguments from which such conclusions were made, with respect to these fluids, it appears from experiment, that although they be so transparent in living animals, and so watery in dropsies, yet in animals in health they differ so much from water, that they not only coagulate when exposed to heat, but also when merely exposed to the air; in which circumstance they agree most with that part of the blood called the *coagulable lymph*, as is evident by collecting this fluid from the surface of the abdomen, thorax, or pericardium of an animal that has been recently killed; for if the fluid thus collected be suffered to rest, exposed to the air it will jelly as the coagulable lymph of the blood does. This is an experiment which Mr Hewson made on a considerable number of animals, viz. on bullocks, dogs, geese, and rabbits, and the result of all the experiments was the same. From among those who concluded these fluids a mere water, should be excepted Drs Haller and Monro, who are of a different opinion.

If immediately after killing an animal in health, a lymphatic vessel be tied up properly, and then cut out of the body and opened, so as to let out the lymph into a cup and expose it to the air, it will jelly as the coagulable lymph of the blood does in the same circumstances; this experiment Mr Hewson has likewise made several times on dogs, asses, and geese. But with respect to that fluid which moistens the cellular substance, or cellular membrane, as it is called, he cannot speak with

with so much precision, since it cannot be collected in animals in health; but when we consider how great a probability there is of the lymphatic vessels absorbing that fluid, we may suspect that it is similar to what moistens the pericardium, thorax, abdomen, &c. especially as Mr Hewson has repeatedly observed, that the lymph returning from the extremities by their lymphatic vessels, coagulates when exposed to the air equally as the lymph nearer the centre of the body.

Since, then, those fluids in healthy animals coagulate spontaneously on being exposed to the air, may we not conclude that they resemble the coagulable lymph of the blood at least more than they do the water, or even than they do the serum, which does not jelly on being exposed to the air? And is it not an argument in favour of this inference, that such a fluid appears fitter for the office of lubrication than mere water, and more similar to the synovia, which of all fluids is the best adapted to that purpose?

But although from these experiments it appears pretty evident that the lymph in these cavities and vessels of an healthy animal will always jelly on being exposed to the air, yet it has been likewise observed that the strength of that jelly is different in different animals. In geese these fluids jelly sooner than in dogs; and in the same animals the jelly differs in the different circumstances of health: in most of the dogs which Mr Hewson examined, the contents of the lymphatics formed a strong jelly; but in a dog which he had fed eight days with bread and water, and that rather sparingly, the lymph formed a very weak jelly; and in young geese these fluids are later in jelling than in such as are full grown. The same thing is true with respect to the fluid contained in the pericardium and abdomen of other animals; which fluid, when in a small quantity, always formed a strong jelly, but when more copious, and the animal more feeble, the jelly is thinner; and in dropsical cases, it is well known that

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the fluid let out of these cavities is not observed to jelly on being exposed to the air, as it does in animals in health; but in some cases it is found to coagulate by heat, like the serum of the blood, and in others it only becomes a little turbid when boiled, owing to the coagulable matter being in very small proportion to the water.

Although this lymph becomes more watery in a weak state of the animal, it is less watery and more coagulable in some diseases.

But, what is a more curious fact, in those cases where fluid contained in the abdomen and pericardium has been compared with that contained in their lymphatic vessels, of animals in different states of health, they were found to agree with one another in the degree of coherence of the jelly which they formed. For when the animal was in perfect health, the lymph from the cavity of the pericardium, abdomen, and pleura, formed a strong jelly, and that in the lymphatics of the neck and extremities was equally firm: When the animal was reduced, as in the dog fed eight days on bread and water, or when the goose was very young, then the jelly, formed by the fluid collected in these cavities, was weak, and that formed by the lymph in the lymphatic vessels was likewise in the same proportion. So that although these fluids vary in the different circumstances of health, yet they always agree with each other.

These fluids likewise, as we have before observed, besides agreeing with one another, approach to the nature of the coagulable lymph of the blood in the circumstance of coagulating when exposed to the air, but they differ from it in the time necessary for that coagulation. In dogs that were seemingly in perfect health, whose blood and whose lymph were let out of their vessels at the same time, the lymph was found to be much later in coagulating than the blood. The time which the blood requires for its coagulation is about

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seven minutes after exposition to the air, but the lymph let out from the lymphatic vessels of the same animals, was found to require half an hour or more for its coagulation. And although the blood coagulates soonest in the weak animals, yet the contents of the lymphatic vessels, or the fluids in these cavities, do not, but seem later in jelling in proportion as the animal is reduced, or as they become more watery.

Moreover, the coagulable lymph of the blood and the lymph of the lymphatic vessels, not only differ from one another in the time which they require for their coagulation when exposed to the air, but also they differ more evidently in the time required for their coagulation in the body when merely at rest, without being exposed to air. As, for instance, in a dog killed whilst in health, and whose veins and lymphatic vessels were tied up immediately after his death, the blood in the veins was completely jellied in six hours, but the lymph in the lymphatic vessels of his neck was perfectly fluid twenty hours after his death, and, being let out at this time, jellied, after being for some time exposed to the air.

There is another change of the lymph very evident, besides those already mentioned; for, it not only is varied from the natural state to the more watery, but also from the natural to the more viscid or coagulable; instances of which occur in those inflammatory crusts that are found, in some diseases, to cover the different parts of the body. Thus, the outside of the heart, and the inside of the pericardium, are sometimes covered with a crust as tough as the size in pleuritic blood; and the surface underneath has marks of inflammation, but is not ulcerated. Probably, therefore, it is the inflammation which produces that change, or which makes the exhalant arteries secrete a lymph with such an increased disposition to coagulate. Add to this, that the change which inflammation thus seems to produce, is just the opposite to that produced by the drop-

sy; for, in the dropsy, the fluid is secreted with an extraordinary quantity of water and too little coagulable matter: but in inflammations the fluid is secreted with a greater proportion of coagulable matter, and with less water; and in some instances it seems to be a pure coagulable lymph, either unchanged by the exhalants, and then coagulating gradually on being at rest, as the coagulable lymph is found to do in the veins that are tied; or else the exhalant vessels have the power of changing its properties, so as to make it coagulate in an instant after being secreted. And this supposition of the exhalants having a power of changing the properties of the lymph, is rendered probable from the following consideration, viz. that it is sometimes found coagulated in the inner surface of the heart, forming a crust similar to what we so often see on the outside. Now as there is a constant current of blood through the heart, unless the lymph forming that crust had coagulated instantly on being secreted, it must have been washed off by the blood. One of the clearest instances of this was observed by Sir John Pringle, in the case of a person who had for some time been subject to palpitation of the heart, but afterwards died apoplectic; when there was found marks of inflammation on the surface of the heart; an abscess on the left ventricle, which must have burst, had not an opening from it been covered and shut up by a small crust or polypus which occupied a space in the ventricle.

Now this crust or polypus, lying over an inflamed surface, had probably been formed by a secretion of the lymph from the inflamed vessels; and being formed in the cavity of the heart where there was a constant current of blood, the lymph of which it was composed must have coagulated instantly on being secreted from the vessels, otherwise it would have been washed off with the current; and as the coagulable lymph is not naturally disposed to coagulate so instantaneously, it is probable that the diseased vessels here possessed the

power of producing that change : and therefore, that as in dropsical habits, where the vessels act weakly, the fluids exhaled are of a watery tenuity ; so in inflammatory cases, where the vessels act strongly, those secreted fluids, in consequence of that strong action, acquire a more viscid and a more coagulable nature.

And moreover, as it appears that the properties of the lymph exhaled upon surfaces, and into cavities, differ so widely in different circumstances, and as we find that pus is often met with in such cavities without ulceration, is it not probable that pus itself is merely that lymph changed in its properties by passing through inflamed vessels ? The cavities of the pleura, pericardium, &c. are sometimes observed to contain considerable quantities of pus without the least mark of ulceration : Instances of which have been not unfrequently seen. In one patient Mr Hewson found three pints of pure pus in the pericardium, without any ulcer either on that membrane or on the heart. In another, the cavity of the pleura of the right-side was distended with a pus that smelt more like whey than a putrid fluid, and the lungs were compressed into a very small compass ; but there was no appearance of ulcer or erosion, either on these organs or on the pleura, but only under the pus was a thin crust of coagulable lymph. In such cases it is manifest the pus must have been formed from the fluids ; and as the exhalant vessels at one time appear to secrete a mere water, at another a coagulable lymph, and in a third (when a little inflamed) they secrete that lymph so viscid, and change its properties so much as to make it coagulate instantly on being secreted ; so in like manner they may sometimes, when more inflamed, have the power of converting the lymph into pus : and, according to the kind and degree of inflammation, the pus may vary from the bland, viscid, and inodorous nature, to that of the most thin and fetid sanies found in phagedenic and cancerous ulcers. And if pus in these cases is

produced merely by a secretion, so likewise it would seem probable, that even in abscesses where there is a loss of substance, it is not the melting down of the solids that gives rise to the pus, but the pus being secreted into the cellular membrane from its pressure, and from other causes, deadens the solids and then dissolves them; which is confirmed by observing, that even a piece of fresh meat, if put into an ulcer and covered up, is soon destroyed or melted down by the pus, which is thereby rendered more fetid. And this opinion, that pus is made by a secretion, is strengthened by observing, that in its pure state it is full of globules; in which circumstance it agrees with milk, which is produced by a secretion, and not by a fermentation.

Upon the whole, then, it appears, that the lymph contained in the lymphatic vessels, and the fluids which moisten the different cavities of the body, as the pleura, peritonæum, &c. instead of being a mere water, in healthy animals, are coagulable fluids, approaching to the nature of the coagulable lymph of the blood, of which probably they are a species, or are composed of a mixture of that lymph with water, that the proportions of that mixture vary from the dropsical habit, where the coagulable lymph is in a small, and the water in a great proportion, up to the rheumatic or inflammatory habit, where the lymph abounds, and the water is in less proportion; and that in some cases the lymph, in passing through inflamed vessels, is even converted into pus.

#### § 1. *Of the Secretion of the Lymph.*

HAVING already spoken of the properties of the lymph moistening the different cavities of the body, we shall next consider the manner in which that lymph is formed or secreted from the mass of blood.

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The most generally received opinions concerning this secretion have been, that it was performed either by small exhalant arteries, or else by pores on the sides of the vessels, which pores were believed to be organized.

But these opinions have been controverted by Dr Hunter in his medical commentaries, who has endeavoured to prove that this secretion was not performed by exhalant arteries, or an effect of what is properly called *organization*, but merely by the thinner or more watery parts of the blood, filtrating or transuding thro' the inorganized interstices between the fibres of our vessels and membranes; so that, according to this idea, the fibres of our vessels were close enough to retain the serum, or the red globules, but not close enough to prevent the water oozing out as through a sieve; and the arguments with which this doctrine is supported are as follow:

First, The ready transudation of watery and other injections after death.

Secondly, The transudation of blood after death, but not during life; for during life he supposes the blood to be thickened by the coagulable lymph; but when that lymph is jellied, he concludes the blood is thereby made thinner, and therefore more capable of oozing through the inorganized interstices, by which it could not pass before.

Thirdly, The transudation of bile, which he thinks takes place in the living body, because on opening a dead one we see all the neighbourhood of the gall-bladder tinged with this fluid.

Such are the arguments brought in favour of transudation; but on a careful examination, they are not so satisfactory as those which may be produced in defence of the opinion that these secretions are by organized passages, as perhaps will appear from the following observations.

First, Although fluids do transude on being injected  
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ed into the vessels of the dead body, yet we must not thence conclude that a similar effect would certainly take place in the living; for it is probable, that our fibres and vessels have a degree of tension which they may lose with life. Besides, if transfusion took place in the living body, it would seem to defeat the principal purpose for which the blood-vessels were made, that is, the containing and conveying the fluids; and upon drinking a greater quantity than ordinary of watery liquors, instead of the liquors being carried to the kidneys or other emunctories, and thereby thrown out of the body as a redundancy, they would escape into the cellular membrane and occasion an anasarca. That this would be the case will appear the more probable, when it is considered how small the fibres of our blood-vessels must be, and therefore what millions of pores (did they exist) the water would be exposed to from its entrance into the stomach, and its passage through the lacteals, the thoracic duct, the veins, the heart, the lungs, and the arteries, before it reached the kidneys. So that were we in imagination to follow a drop of these liquors, according to the idea of transfusion, we should find it, first leaking through the stomach or through a lacteal, then being absorbed, then escaping a second time, and being again absorbed, &c. an idea by no means consistent with what we know of the works of nature. It is more probable, therefore, that as the blood-vessels are made to contain and convey the fluids, nature has taken care to construct them properly to prevent this purpose being defeated.

Secondly, To suppose that the fluids which moisten the different cavities of the body, as the pericardium, pleura, peritonæum, tunica vaginalis, &c. get into these cavities merely by transfusion, is to suppose, not only that the small vessels in contact with these membranes have inorganized pores, but also that these membranes themselves have the same just opposite to those of the vessels. Now if we admit inorganized pores at one part

part of those membranes, we must admit them in all parts, and in the same degree: But as the blood-vessels are circular, and touch those membranes only by a small part of the circle, the parts touched by the vessels must be smaller than the interstices between the vessels, and the lymph must have fewer chances in favour of its leaking from the vessels into the cavities, than of its oozing again from these cavities into the interstices between the vessels or into the cellular membrane; so that, if these membranes admitted of transudation, there would be no such thing as a partial dropsey, for the water would run out at one part of the pleura, pericardium, peritonæum, &c. as fast as it ran in by the other, and an anasarca would always accompany an ascites; which not being a fact leads us to believe, that those membranes do not admit of transudation in living bodies, and that the fluids get into them not by inorganical, but by organized passages.

Thirdly, To prove more satisfactorily that these fluids are not filtrated from the blood merely by inorganical transudation, let us recollect the experiments already related, concerning the properties of those fluids, which we found varied in different circumstances of health. For, in inflammatory affections of the parts from which they were secreted, they assumed the appearance of the coagulable lymph of the blood, and formed a tough jelly; in animals in health they formed a jelly of a weaker nature; and in dropsical cases they were almost a mere water, without the property of coagulation. Now if these fluids be so variable in their properties, it is manifest that the passages secreting them cannot be always unalterably the same, or inorganized; since at one time we find them secreting one fluid, and at another time secreting another; especially as we sometimes find them secreting a fluid very different from the blood, viz. pus. Which pus being found in cavities without any ulcer or erosion, we must conclude it formed by something more than a mere filtration;

for we cannot suppose there should be filtrated from the blood a fluid that was not in it. And if pus, which passes from the same pores, can only be accounted for by supposing these pores to be organisical, in like manner is it not probable, that the secretion of the natural lymph is not a straining through inorganical, but thro' organized passages?

Lastly, It has been brought as an argument in favour of transudation in the living body, that blood transudes after death; and this has been explained on the supposition, that the blood was thicker before the coagulation of the lymph: Which supposition appears ill-founded, when we speak of the living body; for in former experiments we have observed, that this lymph, frequently at least, rather thins than thickens the blood. If, therefore, the blood transudes in the dead and not in the living body, we should rather attribute it to a change in the vessels than in the blood; as is probable from a careful examination of that very fact which has been brought as the principal argument in favour of transudation, viz. the parts adjacent to the gall-bladder being tinged with bile: for any one who will take the trouble of standing by a butcher whilst he kills a sheep, will find, contrary to that gentleman's conclusion, that upon opening the animal immediately, there is no appearance of the gall having transuded, for none of the parts surrounding the gall-bladder are tinged. But let the animal continue a day or two unopened, and then the gall will be found to have transuded, and to have tinged the neighbouring parts; as is the case in the human body by the time that we inspect it.

Since, then, the gall-bladder so readily allows of transudation after death, and not during life, is it not probable that there is in our membranes and our blood-vessels a degree of tension, or a power of preventing the fluids oozing out of them, which power is lost with life?

Upon the whole, then, it appears, that the interstitial,

cial lymph, or the fluid which moistens the different cavities of the body, being different from mere water, cannot be produced simply by transfusion through inorganical interstices; but that there are small exhalant arteries, or organized passages, which not only transmit it from the blood, but change its properties, and adapt it to the office of lubrication, and likewise make it assume very different appearances in different circumstances of health.

§ 2. *Of the supposed Absorption of the Lymph by the red Veins.*

As there is a secretion upon the different surfaces, and into the different cavities of the body for the purposes of the constitution, so there is likewise an inhalation or an absorption. For example; If food be taken into the stomach and intestines, it is there digested, and being converted into chyle, it is in that form taken into the blood-vessels. If garlic be applied to the skin it gets into the body, and is smelt in the breath with as much certainty as when taken into the stomach, where its juices are absorbed by the lacteals. So, likewise, terebinthinate medicines applied to the skin are soon smelt in the urine; and cantharides in a blister affect the urinary passages.

In the same manner fluids are taken from different cavities of the body into the vascular system. Thus the water of an *ascites* and an *anasarca* are occasionally taken up and carried by the blood-vessels to the intestines and kidneys, and evacuated by stool or by urine. And the *pus* of an abscess is sometimes absorbed, and carried to distant parts of the body and there deposited, or is evacuated by the intestines or urinary passages. So also fluids injected into cavities, as that of the chest or belly of living animals, soon find their way into the blood-vessels. These circumstances are admitted by anatomists amongst the unquestionable facts of physiology.

Nor do anatomists differ in their opinions about the

mode in which these fluids are taken up; for it is universally allowed to be by absorption, or that there are small orifices adapted to imbibe them: the only question is, what the vessels are to which these orifices belong, whether to the lymphatic system, or to the common veins?

That the common veins did the office of absorbing both the chyle and the lymph, was the opinion of anatomists before *Asellius* discovered the lacteals; but after his time few doubts were entertained of the lacteals absorbing, at least a part of that fluid. But most anatomists have been so tenacious of the old opinion, as still to believe that the veins partly performed that office, or absorbed some of the chyle, and carried it to the liver.

As to the absorption of the lymph, they have been still more positive of its being performed by the common veins; nay, even after the discovery of the lymphatic vessels, it occurred but to few, that these vessels contributed in the least to this absorption. And no wonder, since besides the respect for the contrary opinion, because it was transmitted from antiquity, anatomists thought themselves possessed of many strong arguments in favour of the common veins performing absorption; and as these arguments still continue to have weight with some modern physiologists, we shall make a particular examination of them in this place.

*First*, That the common veins arise from cavities, especially in the intestines, and to do the office of absorption, is thought probable from injections into these veins in dead bodies having sometimes passed into those cavities, even in cases where but little force was used. This is a circumstance which has occurred in the experiments of the most eminent anatomists, both of the past and of the present age; so that there is no fact in anatomy in favour of which more respectable authorities might be produced. And yet whoever has made numerous experiments with injections, must be convinced

vinced how easy it is to be deceived by them in this matter. For the veins in dead bodies being easily ruptured, whenever we see injections get from them into cavities, we have reason to doubt whether these injections had passed by natural passages or by laceration of the small vessels; and whoever will examine the authorities that have been quoted in defence of this fact, will find that an equal degree of credit has been given to experiments made with such coarse materials as no experienced injector will now believe could pass through such small orifices, as to those injections which from their subtilty leave the point more doubtful. Besides, as we have already found, such changes are produced upon animal bodies by death, that membranes, which during life had been so tense as to prevent transudation, after death were so much altered, that in the gall-bladder, for example, they allowed the viscid bile to pass; does it not therefore become doubtful, when an anatomist injects a cavity from a vein, whether (although he cause no rupture) he may not separate the fibres already relaxed by death, in such a manner as to imitate this transudation? And if one anatomist has been misled when he concluded transudation took place in the living body, because he found it in the dead body, so may they likewise, who have concluded veins arose from cavities in the living because they had been able to push injections into such cavities in the dead body. It must therefore be allowed that such experiments are at the best equivocal. Besides, from the experiments upon living animals, made long ago by Bartholin, and much later by Mr Hunter, &c. (see Dr Hunter's Medical Commentaries), it appears evident, that no absorption by red veins takes place in the living body.

Another argument used in favour of veins arising from cavities, particularly from the intestines, is that some anatomists have affirmed that they have seen white chyle in the blood taken from the mesenteric veins. But this argument will appear very inconclusive, when  
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the reader recollects, that the *serum* of the blood let out from the veins of the arm is sometimes white, which must arise from some other cause than these veins absorbing chyle. And, therefore, if that appearance in the brachial veins can be otherwise accounted for than by absorption, we are left in doubt, whether in those instances, where anatomists observed such a fluid in the veins of the mesentery, it had been owing, not to those veins absorbing it, but to their receiving it from the arteries. All the *serum* of the body being now and then as white as milk.

A third argument produced in support of absorption by the common veins is taken from the structure of the penis, whose veins arise from its cells; which cells, however, are now allowed to be particular organizations, and very different from those of the cellular membrane, and the blood is believed not to be absorbed, but to be impelled from these cells into those veins; and the argument is now given up even by some of those who were once the most strenuous in its favour. (See Dr Monro's State of Facts.) It need not therefore be here dwelt upon.

Ligatures, or compression on the large veins, have been considered as furnishing a fourth argument in favour of these veins arising from cavities, and doing the office of absorption. Thus the swelling of the legs in pregnant women, and in cases where tumors have been seen near the veins, has been explained from the uterus in the one case, and the tumors in the other, occasioning such compression as to prevent the return of the venous blood. But there are two circumstances which make this argument far from being satisfactory. *First*, The lymphatic vessels run near such veins, and it is doubtful whether the lymph may not be retained in the limbs more by the compression of these vessels than by that of the veins. *Secondly*, The compression of a vein may, by stopping the return of the blood, not only distend the small veins, but the small arteries, and the

the exhalants may be so dilated, or so stimulated, as to secrete more fluid than they did naturally. In this way, perhaps, the ligature which Dr Lower made on the *cava inferior* of a dog occasioned the *ascites*. An experiment which Mr Hewson has repeated, but his subject did not live so long as Dr Lower's, as it died in half an hour, and had only a very little water in the abdomen.

Lower has related another experiment which has frequently been quoted by writers on the dropsy ; that is, where he tied the jugular veins of a dog, and the dog's head became dropsical. Now were this an experiment which always succeeded, it would be more decisive ; for when the whole cava was tied, no part of the blood being able to return, all the vessels below, not only the small veins, but the small arteries, must have been extremely distended. Whereas, in this experiment, no such thing would take place ; because the jugular veins so frequently communicate with other vessels, that there would still be a regrefs allowed to the blood. If the neck therefore became œdemitous, it would appear more likely to have been occasioned by the ligature on the veins. But what shows that there must have been some fallacy in Lower's experiment is, that these veins have since been frequently tied without an œdema being produced, or any signs of extravasated lymph. Thus, in not one of the experiments which Mr Hewson made on these veins in living dogs (as related in the first part of his *Experimental Inquiries*) was this effect ever produced : And Baron Van Swieten tied up both the jugular veins, and tho' he kept the dog four days afterwards, did not observe him any way incommoded. In one dog Mr Hewson even cut out both the external jugulars, and kept him near a twelvemonth without observing the least symptom of dropsy. It appears, therefore, that in Lower's experiment, not only the veins, but the lymphatic vessels which lie near them, had been tied ; in which case the lymphatics would burst and occasion these symptoms. But in Mr Hewson's ex-

periment he took care to separate the vein from the lymphatics.

These arguments therefore in favour of absorption being performed by the common veins, which are brought from experiments where ligatures were made on large vessels, seem likewise to be liable to fallacy.

A fifth argument is taken from the structure of the placenta, where it has been concluded there are no lymphatics; and yet there must be absorption, and not a communication of the vessels; neither of which arguments are decisive. For there may be lymphatics in the placenta though not yet discovered; or there may be small vessels passing from the mother to the foetus, though not yet injected.

A sixth argument is furnished by the experiments of some authors; in which experiments, it is affirmed, that fluids injected into the intestines were soon afterwards discovered in their mesenteric veins. The experiment related by the ingenious Kauw Boerhaave, has been the most depended upon in this matter. In which experiment water was injected into the intestines, and those intestines being compressed, the water was afterwards observed to run from the veins; but that some fallacy had crept into this experiment is now probable, from its having been repeated several times by Mr Hunter in a very satisfactory manner, without being attended with the like success \*. In these experiments the intestines were not only filled with water, but the experiment was also repeated with milk, starch dissolved in water and coloured with indigo, a solution of musk in water; yet nothing was absorbed by the veins: and this was readily discovered; for the veins had been previously emptied of their blood, by punctures made into their trunks, and prevented from receiving more by ligatures thrown round their corresponding arteries. It may be observed, at the same time, that in the above experiments, though the veins were found empty, the lac-

\* See Dr Hunter's Medical Commentaries.

lacteals had filled themselves freely. The learned M. de Haller, indeed, in comparing these arguments, says, that in such cases where authority seems to balance authority, he chooses rather to adopt the opinions of those who affirm, than of those who deny the fact. For as he observes, this experiment may easily fail of success; but if it has ever succeeded, we shall not easily find another way of accounting for it, except by allowing that these veins open into the intestines. But with due deference to the opinion of this excellent author, Kauw Boerhaave's experiment is not so conclusive as those alluded to above: for in his, the dog was opened immediately after death, and water being injected into his stomach, that water was seen first to dilute the blood, then to wash it from the vena portarum, and the experiment was continued a considerable time by means of pressing the stomach; which pressure furnishes a strong presumption that the water did not get into the veins by absorption but by a laceration, especially as the experiment continued to succeed for some hours after death.

And lastly, A seventh argument used in favour of common veins absorbing was, that many animals were destitute of any other vessels which could do that office. This was supposed to be the case with birds, fish, and amphibious animals; all of which some anatomists did not hesitate to affirm must want every part of the lymphatic system, and with great appearance of reason; since in the smallest quadruped they could easily find either lacteals or lymphatic glands upon the mesentery; but in the largest bird, or fish, neither lacteal-vessel nor conglobate gland could be seen. And if these animals (laid they) be without the lymphatic system, absorption in them must be performed by other vessels, viz. the common veins; and if in them the common veins can do the office of absorption, why should not they likewise perform it in the human body where such veins equally exist? But this argument

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is overthrown by the lymphatic system being now discovered in all these animals.

Such are the arguments produced in favour of the common veins doing the office of absorption; a doctrine which has lately been espoused by that excellent anatomist Dr Meckel; to whose observations, though agreeing with some already mentioned, it may be necessary to pay a particular attention.

Dr Meckel's conclusions in favour of this doctrine, are made entirely from injections in dead bodies: For having filled the common veins by injecting mercury into the lymphatic glands, into the excretory ducts of the breasts, into the vesicula seminalis, into the hepatic ducts, and into the urinary bladder; he concludes, that the veins open into these parts in the living body to absorb from them. A conclusion which is already proved to be liable to considerable objections, as we never can be sure whether our injection, in getting from these cavities into such veins, had gone by a natural or by forced passage. Dr Meckel does indeed mention, that there were no marks of an extravasation in his experiments. Perhaps it might have been too small for observation. Nay, we have even reason to believe, that as the small vessels of the human body are very close to one another, our injection may sometimes burst from one into another lying in contact with it, without distending the cellular membrane which lies between them. A circumstance which anatomists have sometimes observed, and which Mr Hewson has seen happen even on the mesentery of a turtle; where, upon injecting the lacteals, he has more than once made the mercury pass into the common veins: but in all these cases, on a careful examination, we found it was by rupture, as could readily be distinguished in this animal, whose mesentery is extremely thin and transparent. And that it was actually so, and not by a natural passage, must be evident to every anatomist who considers that this is an experiment which does not always

ways succeed on the mesentery of the turtle, where, if there were natural passages, or if the lactals opened into the veins, the mercury would probably run with great facility.

And the very same circumstance which Dr Meckel has observed of a lymphatic gland, has happened to Mr Hewson sometimes on injecting these glands in diseased cases; that is, he has filled the common veins, and in some instances where he looked for it, he could distinguish the extravasation very readily, and therefore concluded, that in the other cases where the veins were filled, that it was also by an extravasation, though a more obscure one. From this he suspects, that in Dr Meckel's experiment, where he filled the common veins, by injecting into the lymphatic vessels of a diseased gland, a similar deception had taken place; especially as the force applied was considerable, he having used a column of mercury eighteen inches high.

And the supposition of the red veins opening into a lymphatic gland, appears improbable from an observation concerning the structure of the glands, for which we are indebted to Dr Meckel himself, viz. that they are made of a convoluted lymphatic vessel. Now to suppose a lymphatic, which is a vessel given to absorb, should itself, even when convoluted, have a common vein opening into it for absorption from its cavity, does not appear consistent with what we know of nature's operations.

Similar objections might be made to the other experiments related by this very ingenious author; but enough has been said to show how cautious we should be in making conclusions, with respect to the passages of the living body, from experiments made on the dead, where, from the weakness of the vessels, and other circumstances, we are so liable to be deceived.

Upon the whole, on taking a review of the doctrine that the common veins are the instruments of absorption, that doctrine appears to have no other support than

than respect for the authority of our predecessors; for all the arguments in its favour are liable to considerable objections. Let us next, therefore, inquire, whether some other part of the human body may not do that important office?

### § 3. *Of Absorption by the Lymphatic System.*

THIS system, in all animals, we have found, consists of a trunk or thoracic duct, and of two extremities, namely, the lacteals and the lymphatic vessels. The lacteals can be traced from the inner surface of the intestines, where they begin by small orifices, in order to absorb the chyle, and to transmit it through the thoracic duct to the blood vessels. That this is their use, has never been questioned since the first discovery of those vessels, from its always admitting of easy demonstration; that is, by giving an animal milk, and then opening him a few hours after; in which case the same fluid that is seen in his intestines can likewise be seen to have got into his lacteals.

After thus being convinced, that the use of one branch of the system is to absorb, we cannot at first sight but wonder that any anatomist should have hesitated to attribute a similar office to the other. Nevertheless some anatomists have been led to ascribe to the lymphatics a very different use to what they found the lacteals perform; particularly since the time that Nuck first made his experiments, in which he thought he injected these lymphatic vessels from the arteries; and therefore concluded, that they had no other use than as correspondent veins to return the lymph from such arteries as were too small to admit the red blood, or the serum. And in this opinion anatomists were confirmed by the theories of Leeuwenhoeck and of Boerhaave, concerning the gradation in the series of the globules of our fluids, and of the sizes of the vessels destined to convey them; thence the idea of the lymphatic vessels

being small veins continued from arteries became so general amongst physiologists.

But although this idea was so commonly received, yet there were some physiologists who reasoned better on the subject; and amongst the first of these was Glisson, who, in a book published the very year after that in which Bartholin wrote upon the lymphatics, attributes to those vessels the office of carrying back to the blood-vessels the lymph which had lubricated the cavities of the body.

M. Noguez, likewise, in a chapter where he mentions the name of Dr Glisson, speaks of absorption by the lymphatics. Hambergerus also seems to have had this idea of their office: And Frederic Hoffman has expressed the doctrine of the lymphatics being absorbents very completely, in his Medic. Ration. system, lib. 1. sect. 2. cap. 3.

This opinion of the lymphatics being a system of absorbents, has been adopted and supported with additional arguments by Dr Hunter and Dr Monro; who, besides showing the fallacy of the experiments brought in favour of the common veins doing the office of absorption, have advanced the following to prove that the lymphatics perform it.

First, Their great analogy with the lacteals, with which they agree in their coats, in their valves, in their manner of ramifying, in their passage through the lymphatic or conglobate glands, and in their termination in the thoracic duct, and in short in every circumstance with regard to their structure; and thence it is probable they also agree with them in their use. And as the lacteals are known to begin from the surface of the intestines, and to be the absorbents of these parts, the lymphatics may begin from the other cavities of the body, and may absorb the fluids which had lubricated those cavities.

Secondly, The passage of the venereal, variolous, and other poisons into the constitution; these poisons

first making an ulcer, and then being absorbed along with the matter of the ulcer and infecting the whole body. That in such cases they are not absorbed by the common veins, but by the lymphatics, appears from their inflaming these lymphatics in their course, and by their generally inflaming a conglobate gland before they enter the system; a strong argument in favour of their being taken up by the lymphatic vessels, which pass through these glands in their way to the thoracic duct.

These two are the principal arguments by which the doctrine of the lymphatics being a system of absorbents has been supported. Experiments made by injections in the dead body, where such injections have been forced from the arteries into the cellular membrane, and from the cellular membrane into the lymphatics, have been likewise brought in favour of this doctrine, but improperly; and being now given up by those who advanced them, they need not be dwelt upon here.

But our experiments related above, furnish another argument in favour of the lymphatics being a system of absorbents; for in these experiments, we have always found the fluids contained in the different cavities of the body, and that contained in the lymphatics exactly agreeing with one another, in their transparency, in their consistence, &c. And in animals in health, we likewise found, when the one jellied on being exposed to the air, the other did so too; and in the animal reduced by low diet, where the properties of the one were altered, those of the other were so likewise, and exactly in the same manner. So that we now seem to have obtained as decisive an argument in favour of absorption by lymphatics, as we before had of that by the lacteals; for the lacteals were concluded absorbents from their being found to run from the intestines filled with a fluid similar to what was in the cavity of the gut; so we seem here to have the same reason for believing that the lymphatics absorb

sorb from cavities, because they are found to contain a fluid exactly similar to what is observed in these cavities ; a strong argument that the fluid had passed from such cavities into these lymphatics by absorption.

Such, then, seems to be the purpose for which the lymphatic vessels were provided, that is, to do the office of absorption, an office of the greatest importance to the animal ; no wonder, therefore, that there should be a system set apart for performing it, and not only in man and quadrupeds, but also in birds, fish, amphibious animals, and perhaps even in insects of the most perfect kind.

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# SYSTEM OF ANATOMY.

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## PART VII. OF THE HUMAN NERVES.

BY THE LATE DR ALEX. MONRO.

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### C H A P. I.

#### Of the NERVES in General.

1. THE numerous turns which the carotid and vertebral arteries make before they pass thro' the dura mater, these arteries having neither swelling muscles nor pressure of the atmosphere to assist the course of the blood in them after they enter the skull, and their division into innumerable communicating branches in the pia mater, and its processes, show, that the liquors must move more slowly and equally in them than in most other parts of the body.

2. By the assistance of injections and microscopes, the very minute branches of these vessels are discovered to go from the pia mater, into the cortex, cineritious, or ashy-coloured part of the cerebrum, cerebellum, and spinal marrow; whereas we can only see longitudinal vessels, without numerous ramifications or reticular plexuses, in the white medullary substance of these parts.

3. The continuity of the cortex with the medulla of the

the encephalon and spinal marrow is observable with the naked eye, and is more distinctly seen with the assistance of a microscope.

4. In dissecting the brain and cerebellum, we see the small beginnings of the medulla proceeding from the cortex, and can trace its gradual increase by the addition of more such white substance coming from the cortex.

5. Both these substances are very succulent; for being exposed to the air to dry, they lose more of their weight than most other parts of the body do.

6. In several places we can observe the medulla to be composed of fibres laid at each others sides.

7. The medullary substance is employed in forming the white fibrous cords, which have now the name of *nerves* appropriated to them. Within the skull we see the nerves to be the medullary substance continued; and the spinal marrow is all employed in forming nerves.

8. The common opinion concerning the rise of the nerves, founded on a superficial inspection of those parts, is, that the nerves are propagated from that side of the encephalon, at which they go out of the skull. But it having been remarked, after a more strict inquiry, and preparing the parts by maceration in water, that the medullary fibres decussate or cross each other in some parts of the medulla; as for example, at the corpus annulare, and beginning of the spinal marrow: and practical observators having related several examples of people whose brain was hurt on one side, while the morbid symptom, palsy, appeared on the other side of the body, of which I have seen some instances; and experiments made on brutes having confirmed these observations, it has been thought, that the nerves had their rise from that side of the encephalon which is opposite to their egress from the skull. It may, however, still be said, that this last opinion is not fully demonstrated, because a decussation in some parts is not a proof that it obtains universally; and if there are examples of pal-

fy of the side opposite to where the lesion of the brain was, there are also others, where the injury done to the brain and the palsy were both on the same side.

9. The nerves are composed of a great many threads lying parallel to each other, or nearly so, at their exit from the medulla.

This fibrous texture is evident at the origin of most of the nerves within the skull; and in the cauda equina of the spinal marrow, we can divide them into such small threads, that a very good eye can scarce perceive them: but these threads, when looked at with a microscope, appear each to be composed of a great number of smaller threads.

10. How small one of these fibrils of the nerves is, we know not; but when we consider that every, even the most minute part of the body is sensible, and that this must depend on the nerves (which, all conjoined, would not make a cord of an inch diameter) being divided into branches or filaments to be dispersed through all these minute parts, we must be convinced, that the nervous fibrils are very small. From the examination of the minimum visible, it is demonstrated, that each fibre in the retina of the eye, or expanded optic nerve, cannot exceed the size of the 32,400th part of a hair.

11. The medullary substance, of which the nervous fibrils are composed, is very tender, and would not be able to resist forces as the nerves are exposed to within the bones, nor even the common force of the circulating fluids, were not the pia mater and tunica arachnoides continued upon them; the former giving them firmness and strength, and the latter furnishing a cellular coat to connect the threads of the nerves, to let them lie soft and moist, and to support the vessels which go with them.

It is this cellular substance that is distended when air is forced through a blow-pipe thrust into a nerve, and that makes a nerve appear all spongy, after being distended with air till it dries; the proper nervous fibrils shrivelling

shrivelling so in drying, that they scarce can be observed.

12. These coats (§ 11.) would not make the nerves strong enough to bear the stretching and pressure they are exposed to in their course to the different parts of the body; and therefore, where the nerves go out at the holes in the cranium and spine, the dura mater is generally wrapped closely round them, to collect their disengaged fibres into tight firm cords; and that the tension which they may happen to be exposed to may not injure them before they have got this additional coat, it is firmly fixed to the sides of the holes in the bones through which they pass.

13. The nervous cords, thus composed of nervous fibrils, cellular coat, pia and dura mater, have such numerous blood-vessels, that after their arteries only are injected, the whole cord is tinged of the colour of the injected liquor; and if the injection is pushed violently, the cellular substance of the nerves is at last distended with it.

14. A nervous cord, such as has been just now described, has very little elasticity, compared with several other parts of the body. When cut out of the body, it does not become observably shorter, while the blood-vessels contract three-eighths of their length.

15. Nerves are generally lodged in a cellular or fatty substance, and have their course in the interstices of muscles and other active organs, where they are guarded from pressure; but in several parts they are so placed, as if it was intended that they should there suffer the vibrating force of arteries, or the pressure of the contracting fibres of muscles.

16. The larger cords of the nerves divide into branches as they go off to the different parts; the branches being smaller than the trunk from which they come, and making generally an acute angle where they separate.

17. In several places, different nerves unite into one  
S 4 cord,

cord, which is commonly larger than any of the nerves which form it.

18. Several nerves, particularly those which are distributed to the bowels, after such union, suddenly form a hard knot considerably larger than all the nerves of which it is made. These knots were called *corpora ovaria*, and are now generally named *ganglions* \*.

19. The ganglions have thicker coats, more numerous, and larger blood-vessels, than the nerves; so that they appear more red and muscular. On dissecting the ganglions, fibres are seen running longitudinally in their axes, and other fibres are derived from their sides in an oblique direction to the longitudinal ones.

20. Commonly numerous small nerves, which conjunctly are not equal to the size of the ganglion, are sent out from it, but with a structure no way different from that of other nerves.

21. The nerves sent to the organs of the senses, lose there their firm coats, and terminate in a pulpy substance. The optic nerves are expanded into the soft tender webs, the *retinæ*. The auditory nerve has scarce the consistence of mucus in the *vestibulum*, *cochlea*, and semi-circular canals of each ear. The *papillæ* of the nose, tongue, and skin, are very soft.

22. The nerves of muscles can likewise be traced till they seem to lose their coats by becoming very soft; from which, and what we observed of the sensory nerves (§ 21.), there is reason to conclude, that the muscular nerves are also pulpy at their terminations, which we cannot indeed prosecute by dissection.

23. It would seem necessary that the extremities of the nerves should continue in this soft flexible state, in order to perform their functions right: for, in proportion as parts become rigid and firm by age, or any other cause, they lose of their sensibility, and the motions are more difficultly performed.

24. Tho' the fibres in a nervous coat are firmly connected,

\* See Vol. II. p. 63, and Monro on the Nervous System, Tab. xx.  
xxi. xxii. xxiii.

nected, and frequently different nerves join into one trunk, or into the same ganglion ; yet the sensation of each part of the body is so very distinct, and we have so much the power of moving the muscles separately, that, if the nerves are principal agents into these two functions, which I shall endeavour to prove they are, we have reason to believe that there is no union, confusion, or immediate communication of the proper nervous fibrils, but that each fibre remains distinct from its origin to its termination.

25. Changes produced any way upon the coats of the nerves, cannot, however, miss to affect the nervous fibrils. The cellular substance may be too full of liquor, or may not supply enough ; the liquor may not be of a due consistence, or it may be preternaturally obstructed and collected. The pia or dura mater may be too tense, or too lax ; their vessels may be obstructed ; their proper nerves may be violently irritated, or lose their power of acting ; and a great many other such changes may happen, which will not only occasion disorders in particular nerves, but may be a cause of the sympathy so frequently observed among the nerves ; which is so necessary to be attentively regarded in a great many diseases, in order to discover their true state and nature, that, without this knowledge, very dangerous mistakes in the practice of physic and surgery may be committed.

26. Many experiments and observations concur in proving, that when nerves are compressed, cut, or any other way destroyed, the parts served by such nerves, farther from the head or spine than where the injuring cause has been applied, have their sensations, motions, and nourishment weakened or lost ; while no such effects are seen in the parts nearer to the origin of those nerves : and in such experiments where the cause impeding the nerves to exert themselves could be removed, and the structure of the nerves not injured, as for example, when a ligature made upon a nerve and stopping its influence has been taken away, the motion  
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and sensation of the parts soon were restored. From which it would appear, that the nerves are principal instruments in our sensations, motions, and nourishment; and that this influence of the nerves is not inherent in them, unless the communication between these cords and their origin is preserved.

This conclusion is just, notwithstanding that sometimes, upon cutting a nerve, the effects above-mentioned have been felt for a short time, but afterwards the person was sensible of no numbness or immobility: for wherever this is said to have happened, the cut nerve was only one of several which were sent to the member; the want of whose influence was felt no longer, than till the habit was acquired of performing the functions easily by the other nerves.

Nor is it of greater weight as an objection, that sometimes when a ligature is drawn very hard upon a nerve, and then is taken away, the nerve never again recovers its influence upon the parts it is distributed to beyond the ligature, but is of as little effect as if it had been cut through; which is to say, that its texture has been altered beyond recovery. The same thing is to be seen by tying a thread tight round a tender twig of any vegetable; it decays.

27. Experiments and observations show, too, that when parts of the encephalon or spinal marrow have been irritated, compressed, or destroyed, the parts of the body, whose nerves had their origin from such affected parts of the encephalon or spinal marrow, became convulsed, paralytic, insensible, or wasted; and in such cases where the injuring cause could be removed from the origin of the nerves, the morbid symptoms observed in the parts to which these nerves were distributed, went off upon the removal of that cause. From which it is thought reasonable to conclude, that the nerves must not only have a communication with their origin, but that the influence they have upon the parts they

they are distributed to, depends on the influence which they derive from the medulla encephali and spinalis.

28. Tho' the spinal marrow has its own vessels and cineritious substance, which assists to form its medulla ; yet a very large share of the medullary substance within the spine is derived from the encephalon, whose medulla oblongata descends from the head; and the influence of the spinal marrow on its nerves depends in a great measure on this medulla oblongata of the head. Hence an injury done to any part of the spinal marrow, immediately affects all the parts whose nerves have their origin below where the injuring cause is applied. A laxation of a vertebra in the loins makes the lower extremities soon paralytic ; a transverse section of the medulla at the first vertebra of the neck, soon puts an end to life.

29. If such causes produce constantly such effects (§ 26, 27, 28.) in us and other creatures living in nearly the same circumstances as we do, the conclusions already made must be good, notwithstanding examples of children and other creatures being born without brains or spinal marrow ; or notwithstanding that the brains of adult creatures can be much changed in their texture by diseases ; and that tortoises, and some other animals, continue to move a considerable time after their heads are cut off. We may be ignorant of the particular circumstances requisite or necessary to the being or well-being of this or that particular creature ; and we may be unable to account for a great many phenomena ; but we must believe our eyes in the examination of facts ; and if we see constantly such consequences from such actions, we cannot but conclude the one to be the cause and the other the effect. It would be as unjust to deny the conclusions made in the three preceding articles, because of the seemingly preternatural phænomena mentioned at the beginning of this, as it would be to deny the necessity of the circulation of the blood in us and most quadrupeds, because a frog

frog can jump about, or a tortoise can walk long after all the bowels of its thorax and abdomen are taken out, or because the different parts of a worm crawl after it has been cut into a great many pieces. It is therefore almost universally allowed, that the nerves are principal instruments in our sensations, motion, and nourishment; and that the influence which they have is communicated from their origin, the encephalon and medulla spinalis. But authors are far from agreeing about the manner in which this influence is communicated, or in what way nerves act to produce these effects.

30. Some alledge, that the nervous fibres are all solid cords acting by elasticity or vibration; others maintain, that those fibres are small pipes conveying liquors, by means of which their effects are produced.

31. The gentlemen, who think the nervous fibres solid, raise several objections to the other doctrine; which I shall consider afterwards; and endeavour to show the fitness of their own doctrine to account for the effects commonly observed to be produced by the nerves.

The objects of the senses plainly (say they) make impulses on the nerves of the proper organs, which must shake the nervous fibrils: and this vibration must be propagated along the whole cord to its other extremity or origin, as happens in other tense strings; and these vibrations being differently modified, according to the difference of the object, and its different application, produce the different ideas we have of objects.

32. To this account of sensation, it is objected, first, That nerves are unfit for vibrations, because their extremities, where objects are applied to them, are quite soft and pappy (§ 21.), and therefore not susceptible of the vibrations supposed; and if there could be any little tremor made here by the impulse of objects, it could not be continued along the nervous cord, because the cellular substance by which each particular fibre is connected to the neighbouring ones (§ 11.), and

and the fatty substance in which the nervous cord is immersed (§ 15.), would soon stifle any such vibratory motion.

A second objection to this doctrine is, That supposing the nerves capable of vibrations by the impressions of objects, these vibrations would not answer the design. For if what we know of other vibrating strings, to wit, that their tone remains the same, unless their texture, length, or tension is altered, and that different substances striking them do no more than make the sound higher or lower; if these properties are to be applied to nerves, then it will follow, that the same nerve would constantly convey the same idea, with no other variety than of its being weaker and stronger, whatever different objects were applied to it; unless we supposed the nerve changed in its texture, length, or tension, each time a different object is applied; which, it is presumed, nobody will undertake to prove does happen.

Nay, 3dly, If ever such a variety of vibrations could be made, our sensations would notwithstanding be confused and indistinct; because the tremulous nervous fibre being firmly connected and contiguous to several other fibres of the same cord, would necessarily shake them too, by which we should have the notion of the object as applied at all the different parts where the extremities of these fibres terminate.

33. In whatever way the favourers of the doctrine of solid nerves please to apply the elasticity of nerves to the contraction of muscles, their adversaries insist that nerves are too weak to resist such weights as the muscles sustain; they would surely break, especially as they are in a great measure, if not wholly, deprived of their strong coats before they come to the part of the muscle they are immediately to act upon (§ 22.)—The nerves being found to have little or no elasticity to shorten themselves (§ 14.) shows them altogether unfit for such an office as this of contracting muscles in the way proposed.

posed of their acting by elasticity; and when a nerve is viewed with a microscope while the muscles it serves are in action, no contraction or motion is observed in it.—Nay, if they were elastic, they would equally exert their power of contracting muscles nearer to their origin as well as farther from it, when they were put into contraction or vibration, by irritation of any part of them. The former, however, does not happen.

34. As a further objection against either motion or sensation being owing to the elasticity of the nerves, it is said, that if this doctrine was true, the sensations would be more acute, and the contractions of muscles would be greater and stronger, when the parts become firmer and more rigid by age; for then their elasticity is increased: Whereas, on the contrary, it appears (§ 23.) that then the sensations are blunted, and muscular contraction becomes less and weaker.

35. If the nerves were granted to be elastic, and to communicate a springy force to all the parts they are distributed to, they might appear necessary in this view to assist the application of the nutritious particles of the fluids to the sides of the vessels which these particles were to repair; and so far might well enough account for the share which nerves are thought to have in nutrition: But if we cannot make use of elasticity in the other two functions, sensation and motion, we must also endeavour to find out some other way for the nerves to act in nutrition; which will be done afterwards.

36. Having thus stated the reasons for and against the nerves acting as solid strings, let us likewise relate the arguments for nerves being pipes, and the objections to this doctrine.

A great argument of those who think the nerves to be tubes conveying liquors, is the strong analogy of the brain and nerves to other glands of the body and their excretaries, where a manifest secretion of liquor is made in the glands, to be conveyed by the excretaries to the proper places in which it ought to be deposited: they

they think that the vascular texture of the cortex of the encephalon and spinal marrow (§ 2.) the continuation of the cortex in forming the medullary substance (3, 4.) the fibrous texture (§ 5.) and succulent state of this medulla (§ 6.) and its being wholly employed to form the nerves (§ 7.) where the fibrous texture is evident (§ 9.); all these things, say they, conspire to show such a strong analogy between these parts and the other glands of the body, as carries a conviction that there is a liquor secreted in the encephalon and spinal marrow, to be sent out by the nerves to the different parts of the body.

37. The following objections are raised to this argument in favour of liquor conveyed in the nerves from the analogy of the glands. *1st*, Other glands, it is said, have their excretaries collected into a few large pipes, and not continued in such a great number of separate pipes, as far as the places where the liquors are deposited; which last must be the case, if the nerves are the excretaries of the glandular brain. *2dly*, We see the cavities, and can examine the liquors in the excretaries of other glands much smaller than the brain; which cannot be done in the nerves. *3dly*, If the nerves were pipes, they would be so small, that the attraction of the liquors to their sides would prevent that celerity in the motion of the liquors, which is requisite to sensations and motions. *4thly*, If the nerves were pipes, they would be cylindrical ones, and consequently not subject to diseases; or at least we could have no comprehension of the diseases in them.

38. The answer to the *1st* of these objections is, That there are other glands where there is a manifest secretion, and in which the disposition of the excretaries is in much the same way as in the encephalon: the kidneys, for example, have a reticulated cortex of vessels, from which the Eustachian or Bellinian medulla, consisting of longitudinal fibres and a few blood-vessels in the same direction, proceeds; and this medulla is collected into ten, twelve, or more papillæ, each of which

is formed of numerous small separate pipes, which singly discharge the urine into the large membranous tubes; and these united form the pelvis. Upon comparing this texture of the kidneys with that of the encephalon (§ 2, 3, 4, 5, 6, 7, 9.) the analogy will be found very strong.

39. In answer to the 2d objection, in § 37. it is granted, that microscopes, injections, and all the other arts hitherto employed, have not shown the cavities of the nervous fibrils, or the liquors contained in them; and from what was said (§ 10.) of the smallness of the nervous fibrils, it is not to be expected that ever they should be seen. But so long as such a number of little animals can every hour be brought to the objectors, in which they can as little demonstrate the vessels or contained fluids, it will not be allowed to be conclusive reasoning, that because ocular demonstration cannot be given of either the tubes or their contents, therefore they do not exist. For if we have any notion of an animal, it is its being an hydraulic machine, which has liquors moving in it as long as it has life. If, therefore, such little animals have vessels and liquors which we cannot see, why may not some of the vessels and liquors of the human body be also invisible to us?

To avoid this answer to the objection, it is further urged, That though we might not see the nervous tubes or the liquors they contain as they naturally flow; yet if such liquors really exist, they ought to discover themselves, either by a nerve's swelling when it is firmly tied; or that, however subtle their fluids are, they might be collected in some drops, at least, when the cut end of a nerve of a living animal is kept some time in the exhausted receiver of an air-pump. It is affirmed, that neither did the tied nerve swell between the brain and ligature, nor was there any liquor collected in the receiver of the air pump; from which it is concluded, that there is no liquor in the nerves.

Some, who say they have tried these experiments, affirm, that in young animals the nerve does swell

above the ligature, and that a liquor does drill out upon cutting a nerve.—Whether swelling or liquor is seen or is not seen in these experiments, no conclusion for or against a nervous fluid can be made from them; for the swelling of the nerve after it is tied, or the efflux of liquors from its extremity, will never prove either to be the effect of the fluid in the proper nervous fibrils, so long as they might be occasioned by the liquors in the larger vessels of the cellular substance of the nerves; and if these same vessels of the coats of the nerves do not discover their liquors by these experiments, it is far less to be expected that the much more subtle nerves will discover theirs.

40. The 3d objection to the doctrine of the brain being a gland, and the nerves its excretaries, supposes a more rapid motion necessary in the fluid of the nerves than what most of the defenders of the nervous fluid will now allow; and is afterwards to be considered particularly in a more proper place.

41. The 4th objection being, That if nerves are excretaries of a gland, they must be cylindrical pipes, in which no obstructions or diseases would happen; but since we daily see diseases in the nerves, they must therefore not be such excretaries. The answer is, That diseases happen often in the excretaries of other glands, as of the liver, kidneys, &c. notwithstanding their cylindrical form, and their much shorter and less exposed course. When we consider the very tender substance of the brain, the vast complication of vessels there, the prodigious smallness of the pipes going out from it, the many moving powers which the nerves are to undergo the shock of, and the many chances which the vessels, membranes, and cellular substance accompanying the nerves, have of being disordered, and then affecting the nervous fibrils, we have very great reason to be surprised, that these cylindrical pipes are not much more frequently put out of order, by too great or too small a quantity of liquors; by too viscid or too thin fluids; by

liquors consisting of too mild and sluggish particles, or of too acrid pungent ones; by too great or too little motion given to the liquors; by the diameters of the pipes being too much straitened, or too much enlarged; and by a great many other varieties of circumstances which might be thought capable of disturbing the functions of the nerves, supposing them to be cylindrical excretaries of the gland, the brain.

42. The numerous vessels of the encephalon have brought some of the gentlemen who assert the nerves to be solid, to acknowledge, that there is a liquor secreted in the brain: but then they will not allow that this liquor is sent out by the proper nervous fibrils, but that it is poured into the cellular substance in which the nerves lie, to keep them moist and supple, and therefore fit for exerting their elasticity, vibration, &c. by which, in their opinion, the effects commonly ascribed to nerves are produced.

43. Besides the objections already mentioned (§ 32, 33.) against the nerves acting as elastic strings, this opinion has some other difficulties which may be objected to it: for instance, there is not one analogous example in the whole body of liquors secreted in a large gland, to be poured into a cellular substance, as is here supposed; the liquors in the cells of the tela cellularis of other parts are separated from the little arteries which are distributed to these cells.

Further, it cannot be imagined, how a liquor secreted in the cortex of the brain should make its way thro' the medulla, to come out into the cellular membranes on the surface of that medulla.

*Lastly,* A very simple experiment, of injecting water by the artery of any member, and thereby filling the cellular substance of the nerves of that member, shows evidently, that the liquor of the cellular substance of the nerves has the same fountain as the liquor has in the tela cellularis any where else, that is, from the little arteries dispersed upon it.

44. The doctrine of a fluid in the nerves, is not only thus supported by the analogy of the brain and nerves to the other glands and their excretaries, but those who maintain this doctrine mention an experiment which they think directly proves a fluid in the nerves. It is this : After opening the thorax of a living dog, catch hold of and press one or both the phrenic nerves with the fingers, the diaphragm immediately ceases to contract ; cease to compress the nerves, and the muscle acts again : a second time, lay hold of the nerve or nerves some way above the diaphragm, its motion stops. Keep firm the hold of the nerve, and with the fingers of the other hand strip it down from the fingers which make the compression towards the diaphragm, and it again contracts : a repetition of this part of the experiment three or four times, is always attended with the same effects ; but it then contracts no more, strip as you will, unless you remove the pressure to take hold of the nerves above the place first pinched ; when the muscle may again be made to contract, by stripping the nerve down towards it. This experiment I have done with the success here mentioned. Let any one try if he can imagine any other reasonable account of these appearances, than that the pressure by the fingers stopped the course of a fluid in the nerve ; that so much of this fluid as remained in the nerve, betwixt the fingers and diaphragm, was forced into that muscle by stripping ; and when it was all pressed away, the fingers above preventing a supply, the muscle contracted no more till the fingers were removed, and a fresh flow by that means was received from the spinal marrow, or from that part of the nerve which had not yet been so stripped.

It has been objected to the conclusions from this experiment, 1. That the diaphragm is set in motion by stripping the nerve from, as well as towards, this muscle ; and this may be well expected ; for a liquor in such small pipes hindered to flow backwards by ligature, pinching fingers, or even the flow of their liquors from

the fountain, will regurgitate forwards with velocity when pressed backwards. We see it happen in the stalks of tender succulent plants.

2. It is said, that muscles cease to act when their veins are tied, as well as when their arteries or nerves are tied or cut, but that muscles continue to act when their veins are cut: by which it would appear, that the overloading of the vessels is an impediment to the action of muscles; and therefore the ceasing of their action, when their arteries or nerves are tied or cut, may also be owing to the liquor in the branches of these pipes of muscles stagnating when it is not propelled by the flow of more liquor from their trunks, and not to any influence or moving power, which now ceases to be conveyed to them.

It is to be observed, in making the experiments just now mentioned, that the contraction of the muscles ceases soonest when the nerves, and latest when the veins are tied.—That when veins are tied, not only are the vessels overloaded, but all the cellular substance of the muscles is filled with coagulated blood; whereas when the arteries and nerves are tied, the reverse is seen, the muscles are lax, and of less bulk. So that in these cases, the ceasing of the contraction of the muscles seems to depend on very different causes, to wit, a deprivation of necessary liquors in the one, and a redundancy of superfluous blood in the other. An elastic stick may be deprived of its elasticity, by being made either too dry or too wet.

45. Some gentlemen, convinced of the reasonableness of the secretion of a liquor in the brain to be sent out by the nerves, but not comprehending how a fluid could have such a rapid retrograde motion as they imagined was necessary for conveying the impressions of objects made on the extremities of nerves to the sensorium, supposed two sorts of nerves; one that conveyed a liquor for muscular motion and nutrition; the other composed of solid nerves, that were to serve for organs

organs of the senses, to convey the vibrations communicated from objects to the sensorium.

46. To this opinion (§ 45.) the objections against the sensatory nerves acting by vibration (§ 32.) may be made; and there is so little reason to suspect any difference in the texture of the different parts of the brain or nerves, that, on the contrary, the structure is every where similar, and branches of the same nerve often serve both for sensation and motion.

How little necessity there is for supposing extremely rapid motions of the nervous fluid, is to be examined soon.

47. The hypothesis of great celerity in the motion of the fluid of the nerves being necessary, gave also rise to another division of the nerves, into arterious or effluent, and venous or reflucent. It was said, that muscular motion and nutrition depended on the arterious nerves; and that the sensations depended on an accelerated motion of the nervous fluid towards the brain, by the impressions which the objects of the senses make upon the venous nerves. By this supposition, the absurdity of rapid fluxes and refluxes in the same canal was prevented; and an advantage was thought to be gained by it, of saving too great a waste of the fluid of the nerves, which otherwise the encephalon and spinal marrow could not supply in sufficient quantity to answer all the exigencies of life.

48. To this opinion (§ 47.) it has been objected, 1<sup>st</sup>, That there is no example in the body, of a secreted liquor being returned immediately and unmixed to the gland by which it was originally separated from the mass of blood; which would be the case were there venous nerves. 2<sup>dly</sup>, There is no occasion for saving the fluid of the nerves in the way proposed; the organs for secreting that fluid being large enough to supply all that is necessary of it in the common functions of life. 3<sup>dly</sup>, If the fluid of the nerves was to be thus kept in a perpetual circulation, it would soon become too acrid

for continuing with safety in such sensible tender vessels as the brain and nerves are composed of. *4thly,* This hypothesis will not answer the design for which it was proposed : for though the momentary application of an object might cause an acceleration in the fluid of venous nerves, yet if the object was kept applied to the nerves, it would stop their fluid, so that it could not go forward to the brain ; and therefore, according to this doctrine, we should be sensible of no objects, except those whose application to the organs of the senses was momentary.

49. Let us now suppose it probable, that the encephalon and spinal marrow seern a liquor from the blood which is sent into all the nerves, and that by the means of this liquor the nerves perform the offices commonly assigned to them ; it is next necessary to inquire what kind of liquor this is, and how it moves, in order to determine how well its nature and motion are fitted for performing what is expected from it.

50. The liquor of the nerves has been fancied by some to be of a very strong acid or alkaline nature : But since none of our juices appear to be of this sort, and since such liquors irritate and destroy the parts of the body which they are applied to, we cannot conceive how the brain can separate, or the nerves could bear any thing of such an acrid nature. The tenderness and sensibility of these organs must hinder us absolutely from supposing that the liquor of the nerves can be acrid or pungent, or of the nature of spirit of wine, hartshorn, &c.

51. Some have imagined the liquor of the nerves to be capable of vast explosion like gun-powder, or of violent sudden rarefaction like air, or of strong ebullition like boiling-water, or the mixture of acids with alkaline liquors. But as the mass of blood from which this fluid is derived, is not possessed of any such properties, we cannot suppose the blood to furnish what it has not in itself. Besides, all these operations are too violent

violent for the brain or nerves to bear ; and when once they are begun, they are not so quickly controlled or restrained, as experience teaches us the nerves can be made to cease from acting.

52. We are not sufficiently acquainted with the properties of an æther, or electrical effluvia, pervading every thing, to apply them justly in the animal œconomy ; and it is as difficult to conceive how they should be retained or conducted in a long nervous cord. These are difficulties not to be surmounted.

53. The surest way of judging what kind of liquor this of the nerves must be, is to examine the liquors of similar parts of the body. All the glands separate liquors from the blood much thinner than the compound mass itself ; such is the liquor poured into the cavity of the abdomen, thorax, ventricles of the brain, the saliva, pancreatic juice, lymph, &c. Wherever there is occasion for secreted liquors being thick and viscid, in order to answer better the uses they are intended for, nature has provided reservoirs for them to stagnate in, where their thinner parts may be carried off by the numerous absorbent veins dispersed on the sides of those cavities ; or they may exhale where they are exposed to the open air. The mucus of the nose becomes viscid by stagnation ; for when it is immediately secreted, it is thin and watery, as appears from the application of sternutatories, &c. The cerumen of the ears is of a watery consistence when just squeezing out. The mucus of the alimentary canal grows thick in the lacunæ. The bile in the hepatic duct has little more consistence than lymph ; that in the gall-bladder is viscid and strong. The urine is much more watery as it flows from the kidneys, than when it is excreted from the bladder. The seed is thin as it comes from the testicles, and is concocted in the vesiculae seminales, &c.

54. Hence (§ 53.) we may safely conclude, that a thin liquor is secreted in the cortex encephali and spinal

marrow; and seeing the thinness of secreted liquors is generally, as the divisions of the vessels, into small subtle branches, and that the ramifications within the skull are almost infinitely subtle, the liquor secreted in the encephalon may be determined to be among the finest or thinnest fluids.

55. Seeing also that we can observe no large reservoir, where the liquor secreted in the cortical substance is deposited, to have its finer parts taken off, we have reason to think that it goes forward into the nerves in the same condition in which it is secreted.

56. By fine or subtle animal liquors, is meant no more than those which are very fluid, and which seem to consist of a large proportion of watery particles, and a lesser one of the oily, saline, and terrestrial particles. Some of the liquors which we can have in sufficient quantity to make experiments with, are so fluid, and have so little viscosity or cohesion of parts, that when laid upon a piece of clean mirror, they evaporate without leaving a stain. Such is the liquor oozing out from the surface of the pleura, the lymph, and several others.

If then these liquors, which are subject to our examination, the secreting vessels of which are so large that we can see them, have such a small cohesion of parts, it might not be unreasonable to say, that the liquor of the nerves is as much more fine and fluid than lymph as the vessels separating it are smaller; and therefore that the fluid of the nerves is a defecated water, with a very small proportion of the other principles extremely subtilized.

57. Two experiments are said to contradict this opinion of the liquor of the nerves being so fluid and subtle. One is, that upon cutting the cauda equina of a living animal, a liquor as viscid as the white of an egg drops out. The other is, that a wounded nerve yields a glairy sanies. But these do not appear to be the proper fluid of the nerves; since it is evident, that

what

what is discharged in both these cases comes out of the cellular substance involving the nervous fibrils.

58. Considering how many experiments make it evident, that there is a constant uninterrupted stream of liquors flowing through all the canals of animals, which convey liquors composed of particles smaller than the diameter of their canal, which is always the case of the nerves in a natural state, it is surprising how it ever could be thought, that the liquid of the nerves should be obliged to flow from the brain to each muscle the moment we will; or that this liquor should flow back with the like swiftness from the extremity of each nerve, to which an object of sensation is applied. The nerves, as well as the other excretaries of the glands, always are full of liquor; the degree of distention of the canals not being at all times alike even in a sound state. But this happens without inconvenience, as the sides of the canals have a power to accommodate themselves to the present quantity, unless it is very much above or below the natural standard; in both which cases diseases ensue.

59. The motion of the fluid in the nerves is therefore not only constant, but it is also equal, or nearly so: for though the blood in the larger arteries is moved unequally by the unequal forces, the contraction of the ventricle of the heart, and the weaker power, the systole of the arteries; yet the difference between these two moving powers comes to be less and less perceptible as the arteries divide into smaller branches; because of the numerous resistances which the liquors meet with, and because the canals they move in become larger, till in the very small arterious branches there is no sensible difference in the velocity of the liquors from the effect of the heart or arteries. The motion of the fluids must still be more equal in the excretaries of glands, and particularly in those where the vessels have divided into very minute branches, and the liquors have no other propelling force but the heart and arteries,

(See

(see § 1.); therefore the nervous fluid moves constantly, equally, and slowly, unless when its course is altered by the influence of the mind, or by the pressure of some neighbouring active organ.

60. As there is neither proof nor probability of the valves supposed by some in nerves, we are not to assume them in accounting for any phenomena.

61. We have not, and perhaps cannot have, any idea of the manner in which mind and body act upon each other; but if we allow that the one is affected by the other, which none deny, and that the fluid of the nerves (whatever name people please to give it) is a principal instrument which the mind makes use of to influence the actions of the body, or to inform itself of the impressions made on the body, we must allow that the mind can direct this instrument differently, particularly as to quantity and celerity, though we must remain ignorant of the manner how many phenomena depending on this connection of mind and body are produced. Thus we would in vain attempt to account for animals continuing, after their heads were struck off or their hearts were cut out, to perform actions begun before they suffered any injury.

62. Let us now suppose the nervous fluid such as has been argued for, to wit, a very fluid saponaceous water, moving in a constant, equal, slow stream, from the encephalon and spinal marrow, in each of the proper nervous fibres, except when the motion is changed by some accessory cause, such as the mind, pressure of other parts, &c.; and let us examine how well such a supposition will agree with the phenomena of the three great functions, nutrition, sensation, and muscular motion, which the nerves are principal instruments of.

63. In general, we may say, that nerves can carry fluids to the most minute part of the body, to supply what is wasted in any of the solids\*; that the impression made

\* However plausible the above might appear to the Author and some

made by the objects of the senses on the very soft pulpy extremities of the nerves of the organs of the senses, must make such a stop in the equal-flowing nervous fluid, as must instantaneously be perceptible at the fountain-head from which the pipes affected arise; that the constant flow of the liquor of the nerves into the cavities of the muscular fibrillæ, occasions the natural contraction of the muscles, by the as constant nisus it makes to increase the transverse and to shorten the longitudinal diameter of each fibre; and that it is only to allow the mind a power of determining a greater quantity of this same fluid with a greater velocity into what muscular fibres it pleases, to account for the voluntary strong action of the muscles.

64. But since such a superficial account would not be satisfactory, it will be expected, that the principal phenomena of these three functions should be explained by the means of such a fluid as has been supposed, and that the several objections against this doctrine should be answered: let us attempt this; and where we cannot extricate ourselves from difficulties which may be thrown in, let us honestly acknowledge ignorance.

65. " If water, with a very small proportion of oils and salts from the earth, proves a fit nourishment for vegetables, such a liquor as the fluid of the nerves has been described (§ 56.) may not be unfit for repairing the waste in animals.

8. The flow continual motion of this nervous fluid  
(§ 58,

some of his cotemporaries, it is not agreeable to the opinion of many of the later physiologists, particularly to the present Professor Monro, who appears to prove beyond a doubt, that nutrition is performed by means of the arteries. After giving his arguments in favour of this doctrine, he concludes thus: " Upon the whole, I apprehend there are few points in physiology so clear as,

1. That the arteries prepare and directly secrete the nourishment in all our organs.
2. That the nerves do not contain nor conduct the nourishment, but by enabling the arteries to act properly, contribute indirectly to nutrition." See Observations on the Nervous System, p. 78.

(§ 58, 59.) to the most minute parts of the body (§ 10.) is well enough calculated to supply the particles that are constantly worn off from the solids by the circulation of the liquors and necessary actions of life.

5. The greater proportional size of the encephalon in young creatures than in adults, seems calculated for their greater proportional growth: for the younger the animal is, the larger encephalon and speedier growth it has.

6. A palsy and atrophy of the members generally accompanying each other, show, that nourishment, sensation, and motion, depend on the same cause.

7. It was said (§ 26.), that the nerves were principal instruments in nutrition: it was not affirmed, that they were the sole instruments; and therefore an atrophy may proceed from the compression or other lesion of an artery, without being an objection to the doctrine here laid down.

66. a. All objects of sense, when applied to their proper organs, act by impulse; and this action is capable of being increased by increasing the impelling force. In tangible objects, that it is clearly evident; the closer they are pressed to a certain degree, the more distinct perception ensues. Odorous particles need the assistance of air moved rapidly to affect our nose: sapid substances, that are scarce sufficient to give us an idea of their taste by their own weight, are assisted by the pressure of the tongue upon the palate: the rays of light collected drive light bodies before them: sound communicates a vibration to all bodies in harmonic proportion with it.

The impulses made thus by any of these objects on the soft pulpy nerves (§ 21.), which are full of liquor, press their sides or extremities, and their liquor is hindered to flow so freely as it did. The canals being all full (§ 58.) this resistance must instantaneously affect the whole column of fluids in the canals that are pressed, and their origins, and have the same effect as if the impulse

impulse had been made upon the origin itself. To illustrate this by a gross comparison: Let any one push water out of a syringe, through a long flexible pipe fixed to the syringe; and he is sensible of resistance or a push backwards, the moment any one stops the orifice of the pipe, or closes the sides of it with his fingers. This impulse made on the nerves, and thus communicated to their origin, varies according to the strength or weakness, the quickness or slowness, the continuance or speedy removal, the uniformity or irregularity, the constancy or alternation, &c. with which objects are applied to the nerves.

*b.* Whenever any object is regularly applied with due force to a nerve rightly disposed to be impressed by it, and is communicated, as just now explained, to the sensory, it gives a true and just idea of the object to the mind.

*c.* The various kinds of impulses which the different classes of objects make, occasion in animals, which ought to have accurate perceptions of each object, a necessity of having the different organs of the senses variously modified, so that the several impulses may be regularly applied to the nerves in each organ; or, in other words, we must have different organs of the senses fitted to the different classes of objects.

*d.* As the objects have one common property of impulse, so all the organs have most of the properties of the organ of touching in common with the papillæ of the skin. In the nose and tongue this is evident: in some operations of the eyes, we can also perceive this; as we may likewise do in some cases where matter is collected in the internal ear.

*e.* These properties common to the different objects and organs, occasion frequently uncommon effects in the application of an object to an organ proper to another object of sensation: for sometimes we have the same idea as if the object had been applied to its own proper organ; at other times the object is as it were changed,

changed, and we have the idea as if the organ had had its own proper object applied to it. Thus, for example, light is the proper object to be applied to the eye, to give us an idea of colours; yet when all light is excluded from the eyes, an idea of light and colours may be excited in us by coughing, sneezing, rubbing or striking the eye-ball.—A cane vibrating, so as not to excite sound perceptible to the ear, applied to the teeth, raises a strong idea of sound; as a little insect creeping in the meatus auditorius also does. The fingers applied to two rough surfaces, rubbing on each other, are sensible of the sound they make; surgeons of any practice in the cure of fractured bones can bear witness to the truth of this.—The fingers dipped in acid and several other acrid liquors, have a sensation very like to tasting.—Smelling and tasting, every body knows, are subservient and assisting to each other. From such examples we have further proof of one general cause of our sensations, to wit, impulse from the objects; and of such a similarity and relation in the organs, as might give reason for imagining that any one of them would be capable of producing the effect of another, if the impulses of the different objects could be regularly applied to each.—Hence light and sound may affect insects and other animals that have not eyes or ears.

*f.* If the impulse of an object is applied with due force, but irregularly, a confused idea of the object is raised. Distant objects are confused to myopes, as very near ones are to presbytæ.

*g.* If the application of the impulse is regular, but the force with which it is applied too weak, our perception of the object is too faint. One may whisper so low as not to be heard.

*h.* If the application of objects is too violent, and there is any danger of the tender organs of our senses being hurt or destroyed, an uneasy sensation we call *pain* is raised, whatever the organ thus injured is. The object of feeling affects every organ: thus pressure, stretch-

ing, cutting, pricking, acrid salts, pungent oils, great heat, violent cold, &c. occasion pain, where-ever they are applied. Besides, every particular organ can be affected with pain by the too violent application of its own proper object. Too much light pains the eyes; very loud sound stuns the ears; very odorous bodies and too sapid objects hurt the nose and tongue. A pretty sure proof this, that the objects of our senses all act, and that the organs are all impressed, in nearly the same way.

i. Since a middle impulse, neither too small nor too great, is necessary for a clear perception of objects, we would often be in danger of not distinguishing them, if we were not subjected to another law, to wit, that numerous impulses made at once, or in a quick succession to each other, increase our perceptions of objects. Thus, such sound as would not be heard on a mountain-top, will be distinctly heard in a wainscotted chamber.— We feel much more clearly a tangible object when our finger is drawn alongst it than when applied with the same force, but by a single pressure upon it.— We make repeated applications of odorous and sapid objects, when we wish to smell or taste accurately.— The end of a burning stick appears much more luminous when quickly whirled in a circle than when at rest.

k. Whenever the uneasy sensation, pain, is raised by the too strong application of objects, a sort of necessity is as it were imposed upon the mind, to endeavour to get free of the injuring cause, by either withdrawing the grieved part of the body from it, as one retires his hand when his finger is pricked or burnt; or the injuring cause is endeavoured to be forced from the body, as a tenesmus excites the contraction which pushes acrid foeces out of the rectum. In both these operations, a convulsive contraction is immediately made in the lesed part, or in the neighbourhood of it; and if the irritation is very strong or permanent, the greater

greater part of the nervous system becomes affected in that spasmodic or convulsive way.—Is it this necessity which obliges the mind to exert herself in respiration, or in the action of the heart, when the lungs or heart are gorged with blood? or the iris to contract the pupil, when the eye is exposed to strong light? or sneezing to be performed when the nose is tickled? &c.

—Will not a stimulus of any nerve more readily affect those with which it is anywhere connected than the other nerves of the body?—May not this sympathy serve as a monitor of the mind rather to employ the organs furnished with nerves thus connected, to assist in freeing her of any uneasy sensation, than to make use of any other organs?—Will not this in some measure account for many salutary operations performed in the body, before experience has taught us the functions of the organs performing them?

This nisus of the mind to free the body of what is in danger of being hurtful, may serve to explain the phenomena of a great many diseases, when we are acquainted with the distribution of the particular nerves; and from this we can understand the operation of medicines that stimulate; and may learn how, by exciting a sharp, but momentary pain, we may free the body of another pain that would be more durable; and that, by having it thus in our power to determine a flow of the liquor of the nerves to any particular part, for the benefit of that part, or the relief of any other diseased part, we can do considerable service by a right application of the proper medicines.

1. If a pain giving cause is very violent or long continued, it destroys the organs either irrecoverably, or puts them so much out of order, that they only gradually recover. People have been made blind or deaf for all their lives after a violent effect of light on their eyes, or of sound on their ears; and we are frequently exposed to as much light and sound as to make us unfit to see or hear for a considerable time. I would ex-

plain this by a ligature put round the tender branch of an herb. This ligature drawn to a certain degree, may weaken the canals so as to be unfit for the circulation of the juices a good while, till they are gradually explicated and made firm by these juices : A stricter ligature would disorder the structure of the fibres so much, that the liquors could not recover them. The analogy is so plain that it needs no commentary.—Thus the influence of a nerve tied with an artery in the operation of an aneurism, may cease for some time, but be afterwards recovered.

67. (1.) In applying the fluid of the nerves to the action of muscles, it was said, that the natural or involuntary contraction of muscles was the nisus which the nervous fluid, flowing constantly into the muscular fibres, makes to distend these fibrils, by enlarging their transverse diameters and shortening their axes ; and that voluntary contraction was owing to a greater quantity of that nervous liquor determined towards the muscle to be put in action, and poured with greater momentum into the muscular fibrils, by the power of the mind willing to make such a muscle to act, or obliged to do it by an irritating pain-giving cause (§ 66. k.)

(2.) Some object to this account of muscular motion, that if there is no outlet for the liquor supposed to be poured into muscular fibres, muscles would always be in a state of contraction, which they are not ; and if there is a passage from the fibrils, the liquor would flow out as fast as it was thrown in ; and therefore no distention of the fibres, or contraction of the muscles, could be made.

(3.) In answer to this objection, it is observed, that notwithstanding the evident outlet from the arteries into the veins, yet the arteries are distended by the systole of the heart, or any other cause increasing the momentum of the blood.

(4.) It has been also objected to § 1. that, if it was  
VOL. III. U true,

true, the volume of the muscle in contraction necessarily would be considerably increased by so much liquor poured into its fibrils ; whereas it does not appear, by any experiment, that the volume of a muscle is increased by its being put into action.

(5.) To this it has been answered, 1. That when the axes of muscular fibres are shortened, and their transverse diameters are enlarged, the capacities of their fibres, and consequently their volume, may not be changed, the diminution one way balancing the increase in the other. 2. That the spaces between the muscular fibres are sufficient to lodge these fibres when they swell during the contraction of a muscle, without any addition to its bulk ; and that it plainly appears that these spaces between the fibrils are thus occupied, by the compression which the larger vessels of muscles, which run in those spaces, suffer during the action of the muscle ; it is so great as to drive the blood in the veins with a remarkable accelerated velocity.

(6.) Another objection to the action of muscles being owing to the influx of a fluid into their fibrils is, That muscular fibres are distractile, or capable of being stretched ; and therefore, when a fluid is poured into their hollow fibrils, they would be stretched longitudinally, as well as have their transverse diameters increased ; that is, a muscle would become longer, as well as thicker, when it is put into action ; whereas it is certainly known that a muscle is shortened while it acts.

(7.) In answer to this it has been remarked, That though muscular fibrils are distractile, yet they will not yield to or be stretched by every force, however small, that might be applied to them. A cord that can be stretched in length by the weight of a pound or two, would not yield in the least to an ounce or two ; and it must likewise be observed, that gradually as any body is stretched, its resistance to the stretching force increases. A rope may be stretched to a certain length by a pound

pound weight appended to it, which would require two pounds to stretch it very little further; and therefore the general observation of animal fibres being distractile, cannot be a reasonable objection to the account of muscular motion above-mentioned, unless a proof is brought, that the force which the liquid of the nerves must exert upon each fibre of a muscle, in order to make it act, is capable of distracting or stretching the fibres; which has not yet been attempted to be proved.—It would appear from the pain caused by too great an effort of muscles, especially in weak people, that muscular fibres can bear very little distraction without danger of a solution of continuity.

(8.) Muscles ceasing to act when their arteries are tied or cut, and being brought into motion by injecting liquors into the arteries even of a dead animal, has been mentioned as objections to the nervous influence causing their contractions.

To the first of these experiments it may be answered, That the tying or cutting of the nerves sooner produces the effect of making the contraction cease, than stopping the influx of the arterious blood does; and it will be universally allowed, that the influx of blood into muscles is necessary for performing their functions right.

Whoever observes the motion which injecting water, or any other liquor, into the arteries of a dead animal, causes in its muscles, will not compare it to what contraction, whether voluntary or excited by irritation, he may see in a living one.

(9.) If muscular motion depends on the influx of the nervous liquid, the instantaneous contraction of a muscle, when the mind wills to make it act, will be easily understood from the nerves being always full of their liquor (§ 58, 66, a.)

(10.) If either the nerves of any muscle do not furnish a sufficient quantity of their liquor, or if the fibres of a muscle become too easily distractile, such a muscle will be unactive or paralytic.

(11.) If too great a quantity of the liquor of the nerves is determined to a muscle or muscles, by any cause which the mind cannot command, such muscle or muscles will be convulsed.

(12.) If the motion of the liquid of the nerves is not uniform, but by disease becomes irregular, an alternate relaxation and contraction of muscles may be the consequence. Hence trembling palfies, chorea Sancti Viti, &c. Hence also the convulsive tremors which animals have when they lose much blood.

(13.) Though the nerves may not furnish so much liquor as may be sufficient to make muscles contract with strength enough to overcome the resistances to their actions, yet there may be a sufficient quantity of liquor in the nerves to allow the impressions of objects to be conveyed to the sensorium. This may be one cause of a member's being sometimes sensible after it cannot be moved.

(14.) Unless the liquor of the nerves acquires some energy in the brain, which we have no reason to think the circulation of the fluids in the vessels can give it, or unless it has other properties than what we can discover in it, or unless there is an agent regulating its momentum and course to different parts which we are not conscious of ; if some of these, I say, do not obtain, the action of the heart continuing of equal force to propel our liquors, notwithstanding all the resistances that are to it, is not to be explained.

(15.) All muscles, but especially the heart, continue to contract in an irregular way, after they are cut away from the animal to whom they belonged ; which may be owing to the liquors continuing to flow in the small vessels, and being poured irregularly into the muscular fibrillæ.

(16.) It is said, that a muscle cut out of the body continues some time to be capable of contraction ; whereas by tying its arteries or nerves, while it is otherwise entire in the body, it loses its contracting power, which

which therefore does not depend on these organs, the arteries or nerves.

The loss of the power of acting when the arteries or nerves are tied while the muscle is in the body, is denied by some who made the trial; and it might be expected that the motion of a muscle would be more conspicuous where there is no resistance to it, as is the case when it is cut away from all the parts it is connected with, than when its connection remains with parts resisting its contractile efforts.

(17.) After the heart, or any other muscle cut away from an animal, has ceased to contract, its contraction may again be restored, by breathing upon it, or pricking it with any sharp instrument. That heat or pricking should, by their stimulus (§ 66, 4.) occasion contraction in a living creature, may be understood; but how they should have the same effect in a muscle separated from an animal, I know not.

68. Some have thought the ganglions of nerves (§ 18, 19, 20.) to be glandular, and to perform a secretion.—Others, from their firm texture, suppose them to be muscular, and to serve to accelerate the motion of the liquor in the nerves which proceed from them; but as no proof is offered of either of these opinions, they cannot be maintained.—Others would make them serve, 1. To divide a small nerve into many nerves, and by these means to increase the number of nervous branches. 2. To make nerves come conveniently by different directions to the parts to which they belong. 3. To re-unite several small nervous fibres into one large nerve.—Since no proof is brought that these three things cannot be done without the interposition of a ganglion, but on the contrary we see them performed where there are no ganglions, we must continue to acknowledge ignorance concerning the uses of these knots, the ganglions.

## C H A P. II.

## Of the PARTICULAR NERVES.

**I**T is generally said, that there are 40 pair of nerves in all; of which 10 come out from the encephalon, and the other 30 have their origin from the spinal marrow.

Of the ten pair of nerves which come from the encephalon\*, the first is the *olfactory*, which long had the name of the *mamillary processes* of the brain, because in the brutes, cows and sheep, which were most commonly dissected by the ancients, the anterior ventricles of the brain are extended forwards upon these nerves, and adhere so firmly to them, that they seem to make the upper side of the nerves. Each of them being large, where it begins to be stretched out, and gradually becoming smaller as it approaches the cribriform bone, was imagined to resemble a nipple. Those who mistook the ventricles for part of the nerves, observing the cavity in them full of liquor, concluded, that these olfactory nerves served to convey the superfluous moisture of the brain to the holes of the ethmoid bone through which it passed into the nose. But in man, the ventricles of whose brain are not thus extended forwards, these nerves are small, long, and without any cavity, having their origin from the corpora striata, near the part where the internal carotid arteries are about to send off their branches to the different parts of the brain; and in their course under the anterior lobes of the brain, which have each a depression made for lodging them, the human olfactory nerves become larger, till they are extended to the cribriform bone; where

\* For a fuller description with figures of the origin of the nerves, see Soemmering de orig. nervorum.

where they split into a great number of small filaments, to pass through the little holes in that bone; and being joined by a branch of the fifth pair of nerves, are spread on the membrane of the nose †.

The tender structure and sudden expansion of these nerves on such a large surface, render it impossible to trace them far; which has made some authors deny them to be nerves: but when we break the circumference of the cribriform lamella, and then gently raise it, we may see the distribution of the nerves some way on the membrane of the nose, where they form a beautiful net-work.

The contrivance of defending these long soft nerves from being too much pressed by the anterior lobes of the brain under which they lie, is singular; because they have not only the prominent orbital processes of the frontal bone to support the brain on each side, with the veins going into the longitudinal sinus, and other attachments bearing it up, but there is a groove formed in each lobe of the brain itself for them to lodge in.— Their splitting into so many small branches before they enter the bones of the skull, is likewise peculiar to them; for generally the nerves come from the brain in disengaged filaments, and unite into cords, as they are going out at the holes of the bones. This contrivance is the best for answering the purpose they are designed for, of being the organ of smelling; for had they been expanded upon the membrane of the nose into a medullary web, such as the optic forms, it would have been too sensible to bear the impressions of such objects as are applied to the nose; and a distribution in the more common way, of a cord sending off branches, would not have been equal enough for such an organ of sensation.

The second pair of nerves, the *optic*, rising from the thalami nervorum opticorum, make a large curve outwards, and then run obliquely inwards and forwards,

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† See Obs. on the Nervous System, Tab. xxiv.

till they unite at the forepart of the sella turcica ; then soon divide, and each runs obliquely forwards and outwards to go out at its proper hole in the sphenoid bone, accompanied with the ocular artery, to be extended to the globe of the eye, within which each is expanded into a very fine cup-like web, that lines all the inside of the eye, to within a little distance of the edge of the crystalline lens, and is universally known by the name of *retina*.

Though the substance of this pair of nerves seems to be blended at the place where they are joined; yet observations of people whose optic nerves were not joined, and of others who were blind of one eye from a fault in the optic nerve, or in those who had one of their eyes taken out, make it appear, that there is no such intimate union of substance \*; the optic nerve of the affected side only being wasted, while the other was large and plump. And the same observations are contradictory to the doctrine of a decussation of all the nerves (§ 8.): for the disease could be traced from the affected eye to the origin of the nerve on the same side. In many fishes, indeed, the doctrine of decussation is favoured; for their optic nerves plainly cross each other, without any union at the part where they are joined in men and most quadrupeds.

Those people whose optic nerves were not joined, having neither seen objects double, nor turned their eyes different ways, is also a plain proof, that the conjunction of the optic nerves will not serve to account for either the uniform motions of our eyes, or our seeing objects single with two eyes, though it may be one cause of the remarkable sympathy of the one eye with the other in many diseases.

The retina of a recent eye, without any preparation, appears a very fine web, with some blood-vessels coming from its centre to be distributed on it; but, after

\* The decussation of the fibres, and intimate union of the substance of the optic nerves, appear to be greater than is here supposed. See Obs. on Nervous System, Tab. v.

ter a good injection of the arteries that run in the substance of this nerve, as is common to other nerves, it is with difficulty that we can observe its nervous medullary substance.—The situation of these vessels in the central part of the optic nerve, the want of medullary fibres here, and the firmness of this nerve before it is expanded at its entry into the ball of the eye, may be the reason why we do not see such bodies, or parts of bodies, whose picture falls on this central part of the retina.—An inflammation in those arteries of the retina, which several fevers and an ophthalmia are generally attended with, may well account for the tenderness in the eyes, and inability to bear the light, which people have in these diseases.—The over-distention of these vessels may likewise serve to account for the black spots observed on bright-coloured bodies especially, and for that smoky fog through which all objects are seen by people in some fevers.—If these vessels lose their tone, and remain preternaturally distended, no object affects our retina, though the eye externally appears sound; or this may be one cause of an amaurosis or gutta serena.—From a partial distention of these vessels, or paralysis of a part of the retina, the central part, or the circumference, or any other part of objects, may be lost to one or both eyes.

The *third* pair rise from the anterior part of the processus annularis; and piercing the dura mater a little before and to a side of the ends of the posterior clinoid process of the sphenoid bone, run along the receptacula, or cavernous sinuses, at the side of the ephippium, to get out at the foramina lacera: after which each of them divides into branches; of which one, after forming a little ganglion, is distributed to the globe of the eye; the others are sent to the musculus rectus of the palpebra, and to the attollens, adductor, deprimens, and obliquus minor muscles of the eye-ball. These muscles being principal instruments in the motions of the eye-lid and eye-ball, this nerve has therefore got the

the name of the *motor oculi*.—I have frequently observed in convulsions the eye-lids widely opened, the cornea turned upward and outwards, and the eye-balls sunk in the orbit; which well described the conjunct action of the muscles which this pair of nerves serves.

—The distention of a considerable branch of the carotid, which passes over this nerve near its origin on each side, may possibly be the reason of the heaviness in the eye-lids and eyes, after drinking hard or eating much.

The fourth pair, which are the smallest nerves of any, derive their origin from the back-part of the base of the testes; and then making a long course on the side of the annular protuberance, enter the dura mater a little farther back and more externally than the third pair, to run also along the receptacula, to pass out at the foramina lacera, and to be entirely spent on the musculi trochleares, or superior oblique muscles of the eyes. These muscles being employed in performing the rotary motions, and the advancement of the eye-balls forward, by which several of our passions are expressed, the nerves that serve them have got the name of *pathetici*.—Why these small nerves should be brought so far to this muscle, when it could have been supplied easily by the motor oculi, I know not.

The fifth pair are large nerves, rising from the annular processes, where the medullary processes of the cerebellum join in the formation of that tuber, to enter the dura mater near the point of the petrous process of the temporal bones; and then sinking close by the receptacula at the sides of the sella turcica, each becomes in appearance thicker, forms a distinct ganglion, and goes out of the skull in three great branches.

The first branch of the fifth is the *ophthalmic*, which runs through the foramen lacerum to the orbit, having in its passage thither a connection with the sixth pair. It is afterwards distributed to the ball of the eye with the third; to the nose, along with the olfactory, which the

the branch of the fifth that passes through the foramen orbitarium internum joins, as was already mentioned in the description of the first pair. This ophthalmic branch likewise supplies the parts at the internal canthus of the orbit, the glandula lacrymalis, fat, membranes, muscles, and teguments of the eye-lids; its longest farthest extended branch passing through the foramen superciliare of the os frontis, to be distributed to the forehead.

The small fibres which this first branch of the fifth and third pair of nerves send to the eye-ball, being situated on the optic nerve, and, after piercing the sclerotic coat, running along the choroid coat on the outside of the retina in their course to the uvea or iris, may be a cause of the sympathy between the optic nerve and the uvea; by which we more readily acquire the habit of contracting the iris, and thereby lessen the pupil, when too strong light is excluded; and, on the contrary, enlarge the pupil when the light is too faint.—This, with the sympathy which must arise from some of the nerves of the membrane of the nostrils, being derived from this first branch of the fifth pair of nerves, may also be the cause, why an irritation of the retina, by too strong light, may produce sneezing, as if a stimulus had been applied to the membrane of the nose itself;—why pressing the internal canthus of the orbit sometimes stops sneezing;—why irritation of the nose or of the eye causes the eye-lids to shut convulsively, and makes the tears to flow plentifully; and why medicines put into the nose, do often great service in diseases of the eyes.—In the megrim, all the branches of the nerves discover themselves to be affected: for the forehead is racked with pain; the eye-ball is pained, and feels as if it was squeezed; the eye-lids shut convulsively, the tears trickle down, and an uneasy heat is felt in the nose. Hence we can understand where external medicines will have the best effect when applied to remove this disease, to wit, to the mem-

membrane of the nose, and to the fore-head;—why alternate pressure near the superciliary hole of the frontal bone, or sneezing, sometimes gives immediate relief in the megrim;—why the sight may be lost by an injury done to the supra orbital branch;—how it may be restored by agitation of that branch of this nerve.

The second branch of the fifth pair of nerves may be called *maxillaris superior*, from its serving principally the parts of the upper jaw. It goes out at the round hole of the sphenoid bone, and sends immediately one branch into the channel on the top of the antrum maxillare; the membrane of which and the upper teeth are supplied by it in its passage. As this branch is about to go out at the foramen orbitarium externum, it sends a nerve through the substance of the os maxillare to come out at Steno's duct, to be distributed to the fore-part of the palate; and what remains of it escaping at the external orbital hole, divides into a great many branches, that supply the cheek, upper lip, and nostril.—The next considerable branch of the superior maxillary nerve, after giving branches which are reflected through the sixth hole of the sphenoid bone, to join the intercostal where it is passing through the skull with the carotid artery, and the portio dura of the seventh pair as it passes through the os petrosum, is sent into the nose by the hole common to the palate and sphenoidal bone; and the remaining part of this nerve runs in the palato-maxillaris canal, giving off branches to the temples and pterygoid muscles, and comes at last into the palate to be lost.—Hence, the ach in the teeth of the upper jaw occasions a gnawing pain deep-seated in the bones of the face, with swelling in the eye-lids, cheek, nose, and upper lip; and on the other hand, an inflammation in these parts, or a megrim, is often attended with sharp pain in the teeth.—Hence, an obstruction in the duct of the maxillary sinus, which obliges the liquor secreted there to find out a preternatural route

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for itself, may be occasioned by the pain of the teeth.

—Hence, the upper lip often suffers when the palate or nose is ulcerated.

The third, or *maxillaris inferior*, branch of the fifth pair going out of the oval hole of the sphenoid bone, serves the muscles of the lower jaw, and the muscles situated between the os hyoides and jaw: All the salivary glands, the amygdalæ, and the external ear, have branches from it: It has a large branch lost in the tongue, and sends another through the canal in the substance of the lower jaw to serve all the teeth there, and to come out at the hole in the fore-part of the jaw, to be lost in the chin and under-lip.—

Hence a convulsive contraction of the muscles of the lower jaw, or the mouth's being involuntarily shut, a great flow of spittle or salivation, a pain in the ear, especially in deglutition, and a swelling all about the throat, are natural consequences of a violent irritation of the nerves of the lower teeth in the toothach; and pain in the teeth and ear, is as natural a consequence of an angina.—Hence alternate pressure on the chin may sometimes relieve the violence of a toothach.—

Hence destroying the nerves of a tooth by actual or potential cauteries, or pulling a carious tooth, so often removes immediately all these symptoms.—Hence no cure is to be found for some ulcers in the upper or lower jaw, but by drawing a tooth.—Hence, in cancers of the upper lip, the salivary glands are in danger of being affected, or the disease may be occasioned to the lip by its beginning in the glands.—Perhaps the sympathy of the organs of tasting and smelling may in some measure depend on their both receiving nerves from the fifth pair.

The *sixth* pair, which is the smallest except the fourth, rises from the forepart of the corpora pyramidalia; and each entering the dura mater some way behind the posterior clinoid process of the sphenoid bone has a long course below that membrane, and within the receptaculum at the side of the cella turcica, where it is

immersed in the blood of the receptacle; but for what purpose, I am ignorant. It goes afterwards out at the foramen lacerum into the orbit, to serve the abductor muscle of the eye.—A defect in this nerve may therefore be one cause of strabismus.—In the passage of this nerve below the dura mater, it lies very contiguous to the internal carotid artery, and to the ophthalmic branch of the fifth pair of nerves. At the place where the sixth pair is contiguous to the carotid, a nerve either goes from each of them in an uncommon way, to wit, with the angle beyond where it rises obtuse, to descend with the artery, and to form the beginning of the intercostal nerve, according to the common description; or, according to other authors, this nerve comes up from the great ganglion of the intercostal, to be joined to the sixth here.

The arguments for this latter opinion are, That, according to the common doctrine, this beginning of the intercostal nerve, as it is called, would rise in a manner not so ordinary in nerves. In the next place, it is observed, that the sixth pair is larger nearer to the orbit, than it is before it comes to the place where this nerve is said to go off; and therefore it is more probable, that it receives an addition there, rather than gives off a branch. Lastly, It is found, that upon cutting the intercostal nerves of living animals, the eyes plainly were affected; they lost their bright water; the gum, or gore, as we call it, was separated in greater quantity; the pupil was more contracted; the cartilaginous membrane, at the internal canthus, came more over the eye; and the eye-ball itself was diminished.

To this it is answered, in defence of the more common doctrine, 1st, That other branches of nerves go off in a reflected way, as well as this does, supposing it to be the beginning of the intercostal; and that the reflection would rather be greater, if it is thought to come up from the intercostal to the sixth. 2dly, It is denied

denied that this nerve is for ordinary thicker at its fore than at its back-part; and if it was supposed to be thickest nearer to the orbit, the conclusion made above could not be drawn from this appearance, because other nerves enlarge sometimes where there is no addition made to them, as in the instance already mentioned of the trunk of the fifth pair while below the dura mater. 3dly, The experiments on living animals show indeed, that the eyes are affected upon cutting the intercostal nerve; but not in the way which might have been expected, if the intercostal had furnished such a share of the nerve that goes to the abductor muscle of the eye: for it might have been thought, that this muscle would have been so much weakened immediately upon cutting the intercostal, that its antagonist the adductor would have greatly prevailed over it, and have turned the eye strongly in towards the nose; which is not said to be a consequence of this experiment. So that the arguments are still equivocal; and more observations and experiments must be made, before it can be determined with certainty whether the fifth pair gives or receives a branch here. In the mean time, I shall continue to speak about the origin of the intercostal with the generality of anatomists.

At this place where the intercostal begins, the fifth pair is contiguous and adherent to the sixth; and it is generally said, that the ophthalmic branch of the fifth gives a branch or two to the beginning of the intercostal, or receives such from it. Others deny any such communication between them: and those who affirm the communication confess, that in some subjects they could not see it. After examining the nerves here in a great many subjects, I cannot determine whether or not there are nervous filaments going from the one to the other. Sometimes I have thought that I traced them evidently; at other times I observed, that what I dissected for nervous filaments, was collapsed cellular substance; and in all the subjects where I had pushed an injection

injection successfully into the very small arteries, I could only observe a plexus of vessels connecting the one to the other. In any of these ways, however, there is as much connection as, we are assured from many experiments and observations on other nerves, is sufficient to make a very great sympathy among the nerves here.—Possibly the appearances in the eyes of dogs, whose intercostal nerves were cut, might be owing to this sympathy.

The seventh pair comes out from the lateral part of the annular process, behind where the medullary processes of the cerebellum is joined to that tuber; and each being accompanied with a larger artery than most other nerves, enters the internal meatus auditorius, where the two large bundles of fibres, of which it appeared to consist within the skull, soon separate from each other: one of them entering by several small holes into the vestibule, cochlea, and semicircular canals, is stretched on this inner camera of the ear in a very soft pulpy substance; and being never seen in the form of a firm cord, such as the other parcel of this and most other nerves become, is called the *portio mollis* of the auditory nerve\*.

The other part of this seventh pair passes through Galen's foramen cæcum, or Fallopius's aquæduct, in its crooked passage by the side of the tympanum; in which passage, a nerve sent to the lingual branch of the inferior maxillary nerve, along the outside of the tuba Eustachiana, and cross the cavity of the tympanum, where it has the name of *chorda tympani*, is commonly said to be joined to it. The very acute angle which this nerve makes with the fifth, or the sudden violent reflection it would suffer on the supposition of its coming from the fifth to the seventh, appears unusual; whereas, if we suppose that it comes from the seventh to the fifth, its course would be more in the ordinary way, and the *chorda tympani* would be esteemed a branch of the seventh pair going to join the fifth, the size of which is increased by this acquisition. This smaller bundle of the seventh gives branches to the muscles of the malleus,

\* See Obs. on the Nervous System, Tab. xxvii—xxxii.

leus, and to the dura mater, while it passes through the bony crooked canal, and at last comes out in a firm chord named *portio dura*, at the end of this canal, between the styloid and mastoid processes of the temporal bone, giving immediately filaments to the little oblique muscles of the head and to those that rise from the styloid process. It then pierces through the parotid gland, and divides into a great many branches, which are dispersed in the muscles and teguments that cover all the side of the upper part of the neck, the whole face and cranium, as far back as the temples, including a considerable part of the external ear. Its branches having thus a considerable connection with all the three branches of the fifth pair, and with the second cervical, occasion a considerable sympathy of these nerves with it.—Hence in the toothach, the pain is sometimes very little in the affected tooth, compared to what it is all along the side of the head and in the ear.—Hence probably the relief of the toothach from blisters applied behind or before the ear, or by a hot-iron touching the antihelix of the ear.—By this communication or connection possibly too it is, that a vibrating string held between one's teeth, gives a strong idea of sound to the person who holds it, which nobody else can perceive.—Perhaps too the distribution of this nerve occasions the head to be so quickly turned upon the impression of sound on our ears.

The eighth pair \* of nerves rise from the lateral bases the corpora olivaria in disgregated fibres; and as they are entering the anterior internal part of the holes common to the os occipitis and temporum, each is joined by a nerve which ascends within the dura mater from the tenth of the head, the first, second, and inferior cervical nerves: this, every body knows, has the name of the *nervus accessorius*. When the two get out of the skull, the accessorius separates from the eighth, and, descending obliquely outwards, passes through the sternomastoideus

\* For a beautiful and accurate figure of this nerve, see Walter's Tab. Nervorum thoracis et abdominis.

mastoideus muscle, to which it gives branches, and afterwards terminates in the trapezius muscle of the scapula. In this course it is generally more or less joined by the second cervical nerve.—Why this nerve, and several others which are distributed to muscles, are made to pierce through muscles, which they might have only passed near to, I do not know.

The large eighth pair, soon after its exit, gives nerves to the tongue, larynx, pharynx, and ganglion of the intercostal nerve; and being disjoined from the ninth and intercostal, to which it adheres closely some way, runs straight down the neck behind the internal jugular vein, and at the external side of the carotid artery. As it is about to enter the thorax, a large nerve goes off from the eighth of each side: this branch of the right side turns round from the fore to the back part of the subclavian artery, while the branch of the left side turns round the great curve of the aorta; and both of them mounting up again at the side of the œsophagus, to which they give branches, are lost at last in the larynx \*. These are called the *recurrent nerves*, which we are desired to shun in the operation of bronchotomy, though their deep situation protects them sufficiently.—The muscles of the larynx being in a good measure supplied with nerves from the recurrents, it is to be expected, that the cutting of them will greatly weaken the voice, though it will not be entirely lost so long as the superior branches of the eighth pair are entire.—Why the recurrent nerves rise so low from the eighth pair to go round a large artery, and to have such a long course upwards, I know not.

The eighth pair, above and at or near the place where the recurrent nerves go off from it, or frequently the recurrents themselves, send off small nerves to the pericardium, and to join with the branches of the intercostal

\* The recurrent and superior laryngeal nerves are joined together by their apices, to form a plexus resembling that of the nerves of the face; so that from both these nerves each muscle of the larynx receives branches. See Obs. on the Nervous System, Tab. xxv.

costal that are distributed to the heart; but their size and situation are uncertain.

After these branches are sent off, the par vagum on each side descends behind the great branch of the trachea, and gives numerous filaments to the lungs, and some to the heart in going to the œsophagus. The one of the left side running on the forepart of the œsophagus, communicates by several branches with the right one in its descent to be distributed to the stomach: the right one gets behind the œsophagus, where it splits and rejoins several times before it arrives at the stomach, to which it sends nerves; and then being joined by one or more branches from the left trunk, they run towards the cæliac artery, there to join into the great semilunar ganglion formed by the two intercostals.

From the distribution of this par vagum, we may learn, how tickling the fauces with a feather or any such substance, excites a nausea and inclination to vomit;—why coughing occasions vomiting, or vomiting raises a cough.—Hence we see how the nervous asthma and the tussis convulsiva, chincough, are attended with a straitening of the glottis;—why food difficult to digest occasions the asthma to weakly people; and why emetics have frequently cured the asthma very speedily;—why an attempt to vomit is sometimes in danger of suffocating asthmatic people;—why the superior orifice of the stomach is so sensible as to be looked on as the seat of the soul by some;—why people subject to distentions of the stomach, have so often the sensation of balls in their breast and throat;—why the globus hystericus is so often attended with a violent strangulation at the glottis.

The ninth pair of nerves comes from the inferior part of the corpora pyramidalia, to go out of the skull at their proper holes of the occipital bone. After their egress they adhere for some way firmly to the eighth and intercostal; and then sending a branch, that in many subjects is joined with branches of the first and second cervical nerves, to be distributed to the thyroid gland, and muscles on the forepart of the trachea arteria, the

ninth is lost in the muscles and substance of the tongue. Some have thought this nerve, and others have esteemed the third branch of the fifth pair of nerves, to be the proper gustatory nerve. I know no observation or experiments to prove either opinion, or to assure us that both nerves do not serve for tasting and for the motion of the tongue.—May not the distribution of this nerve to the muscles below as well as above the os hyoides, contribute to their acting more uniformly in depressing the lower jaw or head?

The tenth pair rises in separate threads from the sides of the spinal marrow, to go out between the os occipitis and first vertebra of the neck. After each of them has given branches to the great ganglion of the intercostal, 8th, 9th, and 1st cervical nerves, it is distributed to the straight, oblique, and some of the extensor muscles of the head. Whether the name of the tenth of the head, or of the first vertebral, ought to be given to this pair of nerves, is of no such consequence as to deserve a debate, though it has some of the marks of the spinal nerves, to wit, its being formed of filaments proceeding from both the fore and back part of the medulla, and a little ganglion being formed where these filaments meet.

In the description of the fifth pair, I followed the usual way of speaking among anatomists, and called that the beginning of the intercostal nerve which comes out of the skull; and therefore shall here subjoin a cursory description of this nerve, notwithstanding its much larger part is composed of nerves coming out from the spinal marrow. There is no greater incongruity in point of method to say, that the nerve we are describing receives additions from others that have not been described, than it is to repeat in the description of a great many nerves, that each of them gives branches to form a nerve which we are ignorant of; which is all the difference between describing the intercostal before or after the spinal nerves.

The

The branch reflected from the sixth pair, joined possibly by some filaments of the ophthalmic branch of the fifth, runs along with the internal carotid artery, thro' the crooked canal formed for it in the temporal bone, where the little nerve is very soft and pappy, and in several subjects divides and unites again, and is joined by one or more branches from the fifth, particularly of its superior maxillary branch, before it comes out of the skull. May the compression of this nerve by the carotid artery, when stretched during the systole, contribute to the diastole of the heart? As soon as the nerve escapes out of this bony canal, it is connected a little way with the eighth and ninth; then separating from these, after seeming to receive additional nerves from them, it forms a large ganglion, into which branches, from the tenth of the head, and from the first and second cervical, enter. From this ganglion the nerves come out again small to run down the neck along with the carotid artery, communicating by branches with the cervical nerves, and giving nerves to the muscles that bend the head and neck. As the intercostal is about to enter the thorax, it forms another ganglion, from which nerves are sent to the trachea and to the heart; those designed for the heart joining with the branches of the eighth, and most of them passing between the two great arteries and the auricles to the substance of that muscle. The intercostal \* after this consisting of two branches, one going behind, and the other running over the forepart of the subclavian artery, forms a new ganglion, where the two branches unite below that artery; and then descending along the sides of the vertebræ of the thorax, receives branches from each of the dorsal nerves; which branches appearing to come out between the ribs, have given the name of *intercostal* to the whole nerve. Where the addition is made to it from the fifth dorsal nerve, a branch goes off obliquely forwards; which being joined by such branches from the sixth, seventh, eighth, and ninth

\* See Walter's Tab. Nervor. thor. et abd.

dorsal, an anterior trunk is formed, and passes between the fibres of the appendix musculosa of the diaphragm, to form, along with the other intercostal and the branches of the eighth pair, a large semilunar ganglion, situated between the cæliac and superior mesenteric arteries: the roots of which are as it were involved in a sort of nervous net-work of this ganglion, from which a great number of very small nervous threads runs out to be extended on the surface of all the branches of those two arteries, so as to be easily seen when any of the arteries are stretched, but not to be raised from them by dissection; and thus the liver, gall-bladder, duodenum, pancreas, spleen, jejunum, ilium, and a large share of the colon, have their nerves sent from this great solar ganglion or plexus.—May not the peristaltic motion of the intestines depend in some measure on the passage of the intercostal nerves through the diaphragm?

Several fibres of this ganglion, running down upon the aorta, meet with other nerves sent from the posterior trunk of the intercostal, which continues its course along the sides of the vertebræ: they supply the glandulae renales, kidneys, and testes in men, or ovaria in women; and then they form a net-work upon the inferior mesenteric artery where the nerves of the two sides meet, and accompany the branches of this artery to the part of the colon that lies in the left side of the belly, and to the rectum, as far down as to the lower part of the pelvis.

The intercostal continuing down by the side of the vertebræ of the loins, is joined by nerves coming from between these vertebræ, and sends nerves to the organs of generation and others in the pelvis, being even joined with those that are sent to the inferior extremities.

The almost universal connection and communication which this nerve has with the other nerves of the body, may lead us to understand the following and a great many more phenomena:—Why tickling the nose causes

ses sneezing :—Why the too great quantity of bile in the cholera occasions vomiting as well as purging :—Why people vomit in colics, in inflammations, or other irritations of the liver, or of the ducts going from it and the gall-bladder :—Why a stone in the kidneys, or ureters, or any other cause irritating those organs, should so much more frequently bring on vomiting and other disorders of the stomach, than the stone or any other stimulating cause in the bladder does :—Why vomiting is a symptom of danger after child-birth, lithotomy, and other operations on the parts in the pelvis :—Why the obstructions of the menses are capable of occasioning strangulations, belching, colics, stomach-aches, and even convulsions in the extremities :—Why vesicatories, applied from the ears to the clavicles of children labouring under the *tussis convulsiva*, are frequently of great service :—Why worms in the stomach or guts excite an itching in the nose, or grinding of the teeth :—Why irritations in the bowels or the belly occasion sometimes universal convulsions of the body.

The SPINAL NERVES rise generally by a number of disengaged fibres from both the fore and back part of the medulla spinalis ; and soon after form a little knot or ganglion, where they acquire strong coats, and are extended into firm cords ; but the ganglion is entirely formed by the posterior bundle. They are distinguished by numbers, according to the vertebræ from between which they come out ; the superior of the two bones forming the hole through which they pass, being the one from which the number is applied to each nerve. There are generally said to be thirty pair of them : seven of which come out between the vertebræ of the neck, twelve between those of the back, five between those of the loins, and six from the false vertebræ.

The *first* cervical pair of nerves comes out between the first and second vertebræ of the neck ; and having

given branches to join with the tenth pair of the head, the second cervical and intercostal, and to serve the muscles that bend the neck, it sends its largest branches backwards to the extensor muscles of the head and neck; some of which piercing through these muscles, run up on the occiput to be lost in the teguments here; and many fibres of it advance so far forward as to be connected with the fibrils of the first branch of the fifth pair of the head, and of the portio dura of the auditory nerve.—Hence possibly it is, that a clavus hystericus changes suddenly sometimes from the forehead to a violent pain and spasm in the back-part of the head and neck.

The second cervical is soon joined by some branches to the ninth of the head and intercostal, and to the first and third of the neck; then has a large branch that comes out at the exterior edge of the sterno-mastoideus muscle, where it joins with the accessorius of the eighth pair; and is afterwards distributed to the platysma myoides, teguments of the side of the neck and head, parotid gland, and external ear, being connected to the portio dura of the auditory nerve, and to the first cervical. The remainder of this second cervical is spent on the levator scapulæ and the extensors of the neck and head. Generally a large branch is here sent off to join the accessorius of the eighth pair, near the superior angle of the scapula.

To the irritation of the branches of this nerve it probably is, that in an inflammation of the parotid gland, the neck is pained so far down as the clavicle, the head is drawn towards the shoulder of the affected side, and the chin is turned to the other side.—In opening the external jugular vein, no operator can promise not to touch some of the cutaneous branches of this nerve with the lancet; which occasions a sharp pricking pain in the mean time, and a numbness of the skin near the orifice for some time after.

The *third* pair of the neck passes out between the  
2 third

third and fourth cervical vertebræ; having immediately a communication with the second, and sending down a branch, which, being joined by a branch from the fourth cervical, forms the *phrenic* nerve. This descending enters the thorax between the subclavian vein and artery; and then being received into a groove formed for it in the pericardium, it has its course along this capsula of the heart, till it is lost in the middle part of the diaphragm. The right phrenic has a straight course; but the left one is obliged to make a considerable turn outwards to go over the prominent part of the pericardium, where the point of the heart is lodged. Hence, in violent palpitations of the heart, a pungent acute pain is felt near the left orifice of the stomach.—The middle of the diaphragm scarce could have been supplied by any other nerve which could have had such a straight course as the phrenic has. If the subclavian artery and vein have any effect upon this nerve, I do not know it.

The other branches of the third cervical nerve are distributed to the muscles and teguments at the lower part of the neck and top of the shoulder. No wonder then that an inflammation of the liver or spleen, an abscess in the lungs adhering to the diaphragm, or any other cause capable of irritating the diaphragm, should be attended with a sharp pain on the top of the shoulder, as well as wounds, ulcers, &c. of this muscle itself.—If the irritation of this muscle is very violent, it may occasion that convulsive contraction of the diaphragm which is called an *hiccough*; and therefore an hiccough in an inflammation of the liver has been justly declared to be an ill symptom.

An irritation of the thoracic nerves which produces sneezing, may sometimes free the phrenic nerves from any spasm they occasion: so that sneezing sometimes takes away the hiccough; and a derivation of the fluid of the nerves any other way may do the same thing: or the hiccough may also be sometimes cured, by drawing

ing up into the nose the smoke of burning paper or other acrid fumes, swallowing pungent or aromatic medicines, and by a surprise, or any other strong application of the mind in thinking, or in distinguishing objects: or, when all these have failed, it has been put away by the brisk stimulus of a blistering plaster applied to the back.

The *fourth cervical nerve*, after sending off that branch which joins with the third to form the phrenic, and bestowing twigs on the muscles and glands of the neck, runs to the arm-pit, where it meets with the *fifth, sixth, and seventh cervicals*, and *first dorsal*, that escape in the interstices of the *musculi scaleni*, to come at the arm-pit, where they join, separate, and rejoin, in a way scarce to be rightly expressed in words; and, after giving several considerable nerves to the muscles and teguments which cover the thorax, they divide into several branches, to be distributed to all the parts of the superior extremity. Seven of these branches I shall describe under particular names.

1. *Scapularis* runs straight to the *cavitas semilunata* of the upper costa of the scapula, which is a hole in the recent subject, by a ligament being extended from one angle of the bone to the other, giving nerves in its way to the muscles of the scapula. When it has passed this hole, it supplies the *supra-spinatus muscle*; and then descending at the anterior root of the spine of the scapula, it is lost in the other muscles that lie on the dorsum of that bone.

2. *Articularis* sinks downwards at the axilla, to get below the neck of the head of the *os humeri*, and to mount again at the back-part of it; so that it almost surrounds the articulation, and is distributed to the muscles that draw the arm back, and to those that raise it up.

3. *Cutaneus* runs down the fore-part of the arm near the skin, to which it gives off branches; and then divides on the inside of the fore-arm into several nerves, which supply

supply the teguments there, and on the palm of the hand.—In opening the basilic vein of the arm at the ordinary place, the same symptoms are sometimes produced as in opening the external jugular vein, and from a like cause, to wit, from hurting a branch of this cutaneous nerve with the lancet.

4. *Musculo-cutaneus*, or perforans *Casseri*, passes thro' the coraco-brachialis muscle; and after supplying the biceps flexor cubiti and brachioradialis internus, passes behind the tendon of the biceps, and over the cephalic vein, to be bestowed on the teguments on the outside of the fore-arm and back of the hand.—This nerve is sometimes hurt in opening the cephalic vein, and causes pain and numbness for a short time.

5. *Muscularis* has a spiral course from the axilla, under the os humeri, and backward to the external part of that bone, supplying by the way the extensor muscles of the fore-arm, to which it runs between the two brachioradialis muscles, and within the supinator radii longus.—At the upper part of the fore-arm, it sends off a branch which accompanies the supinator longus till it comes near the wrist, where it passes obliquely over the radius, to be lost in the back of the hand and fingers.—The principal part of this nerve pierces through the supinator radii brevis, to serve the muscles that extend the hand and fingers, whose actions are not injured when the supinator acts. Part of this nerve seems to be lost upon the ligament of the wrist \*.

6. *Ulnaris* is extended along the inside of the arm, to give nerves to the muscles that extend the fore-arm and to the teguments of the elbow: towards the lower part of the arm, it slants a little backward to come at the groove behind the internal condyle of the os humeri, through which it runs to the ulna: in its course along this bone, its serves the neighbouring muscles and teguments; and as it comes near the wrist, it detaches a branch obliquely over the ulna to the back of the hand, to be lost in the convex part of several

\* See Obs. on the Nervous System, Tab. xxvi,

ral fingers. The larger part of the nerve goes straight forward to the internal side of the os pisiforme of the wrist; where it sends off a branch, which sinks under the large tendons in the palm, to go cross to the other side of the wrist, serving the musculi lumbricales and interossei, and at last terminating in the short muscles of the thumb and fore-finger. What remains of the ulnar nerve after supplying the short muscles of the little-finger, divides into three branches; whereof two are extended along the sides of the sheath of the tendons of the flexors of the little-finger, to furnish the concave side of that finger; the third branch is disposed in the same way upon the side of the ring-finger next to the little-finger.

When we lean or press on the internal condyle of the os humeri, the numbness and prickling we frequently feel, point out the course of this nerve. I have seen a weakness and atrophy in the parts which I mentioned this nerve to be sent to, after a wound in the internal lower part of the arm.

7. *Radialis* accompanies the humeral artery to the bending of the elbow, serving the flexors of the cubit in its way; then passing through the pronator radii teres muscle, it gives nerves to the muscles on the fore-part of the fore-arm, and continues its course near to the radius, bestowing branches on the circumjacent muscles. Near the wrist, it sometimes gives off a nerve which is distributed to the back of the hand, and the convex part of the thumb and several of the fingers, instead of the branch of the muscular. The larger part of this nerve, passing behind the annular ligament of the wrist, gives nerves to the short muscles of the thumb; and afterwards sends a branch along each side of the sheath of the tendons of the flexors of the thumb, fore-finger, mid-finger, and one branch to the side of the ring-finger, next to the middle one, to be lost on the concave side of those fingers.

Though the radial nerve passes through the pronator muscle,

muscle, and the muscular nerve seems to be still more unfavourably placed within the supinator brevis ; yet the action of these muscles does not seem to have any effect in hindering the influence of these nerves ; for the fingers or hand can be bended while pronation is performing vigorously, and they can be extended while supination is exercised.

The manner of the going off of these nerves of the fingers, both from the ulnar and radial, is, that a single branch is sent from the trunk to the side of the thumb and little finger farthest from the other fingers ; and all the rest are supplied by a trunk of a nerve, which splits into two some way before it comes as far as the end of the metacarpus, to run along the sides of different fingers that are nearest to each other.

It might have been observed, that, in describing the posterior branches of the ulnar and muscular nerve, I did not mention the particular fingers, to the convex part of which they are distributed. My reason for this omission is, the uncertainty of their distribution ; for though sometimes these posterior branches go to the same fingers, to the concave part of which the anterior branches of the ulnar and radial are sent, yet frequently they are distributed otherwise.

The situation of these brachial nerves in the axilla, may let us see how a weakness and atrophy may be brought on the arms by long-continued pressure of crutches, or such other hard substances on this part ; and the course of them from the neck to the arm may teach us how much better effects vesicatory, or stimulating nervous medicines, would have, when applied to the skin covering the transverse processess of the vertebræ of the neck, or at the axilla, than when they are put between the shoulders, or upon the spinal processess, in convulsions or palsies of the superior extremities, where a stimulus is required.

The twelve dorsal nerves of each side, as soon as they escape from between the vertebræ, send a branch forward

ward to join the intercostal, by which a communication is made among them all; and they soon likewise give branches backward to the muscles that raise the trunk of the body, their principal trunk being extended outwards to come at the furrow in the lower edge of each rib, in which they run toward the anterior part of the thorax, between the internal and external intercostal muscles, giving off branches in their course to the muscles and teguments of the thorax.

The *first* dorsal, as was already observed, is particular in this, that it contributes to form the brachial nerves; and that the two branches of the intercostal, which come down to the thorax, form a considerable ganglion with it.

The *six* lower dorsal nerves give branches to the dia-phragm and abdominal muscles.

The *twelfth* joins with the first lumbar, and bestows nerves on the *muscuius quadratus lumborum* and *ilia-cus internus*.

May not the communications of all these nerves be one reason, why the parts they serve act so uniformly and conjunctly in respiration, and conspire together in the convulsive motions of coughing, sneezing, &c.—The twitching spasms that happen sometimes in different parts of the muscles of the abdomen, by an irritation on the branches of the lower dorsal nerves, are in danger of occasioning a mistake in practice, by their resemblance to the cholic, nephritis, &c.—The communications of these lower ones with the intercostals, may serve to explain the violent effort of the abdominal muscles in a *tenesmus*, and in child-bearing.

As the intercostal is larger in the thorax than any where else, and seems to diminish gradually as it ascends and descends, there is cause to suspect that this is the trunk from which the superior and inferior pairs are sent as branches.

The *five* lumbar nerves on each side communicate

with the intercostal and with each other, and give branches backwards to the loins.

The *first* communicates with the last dorsal, sends branches to the abdominal muscles, to the psoas and iliacus, and to the teguments and muscles on the fore-part of the thigh; while its principal branch joins with the other nerves, to form the crural nerve.

The *second lumbar* nerve passes through the psoas muscle, and is distributed nearly in the same way as the former; as is also the *third*.

Branches of the second, third, and fourth, make up one trunk, which runs along the fore-part of the pelvis; and passing in the notch at the fore-part of the great hole common to the os pubis and ischium, is spent on the adductor muscles, and on the teguments on the inside of the thigh. This nerve is called the *obturator*, or *posterior crural nerve*.

By united branches from the first, second, third, and fourth lumbar nerves, a nerve is formed that runs along the psoas muscle, to escape with the external iliac vessels out of the abdomen, below the tendinous arcade of the external oblique muscle. This nerve, which is named the *anterior crural*, is distributed principally to the muscles and teguments on the fore-part of the thigh. A branch, however, of this nerve runs down the inside of the leg to the upper part of the foot, keeping near to the vena saphena; in opening of which with a lancet at the ankle, the nerve is sometimes hurt, and occasions sharp pain at the time of the operation, and numbness afterwards.

The remainder of the fourth lumbar and the fifth join in composing the largest nerve of the body, which is soon to be described.

Whoever attends to the course of these lumbar nerves, and of the spermatic vessels and nerves upon the psoas muscle, with the oblique passage of the ureter over that muscle, will not be surprised, that when a stone is passing in this canal, or even when it is inflamed, the trunk  
of

of the body cannot be raised erect, without great pain; or that the skin of the thigh becomes less sensible, and the thigh is drawn forward, and that the testicle often swells and is drawn convulsively towards the ring of the abdominal muscles.

The six pair of the false *vertebræ* consist each of small posterior branches sent to the hips, and of large anterior branches.

The first, second, and third, after coming thro' the three upper holes in the fore-part of the os sacrum, join together with the fourth and fifth of the loins, to form the largest nerve of the body, which is well known by the name of *sciatic* or *ischiatic* nerve: This, after sending large nerves to the different parts of the pelvis, and to the external parts of generation and the podex, as also to the muscles of the hips, passes behind the great tuber of the os ischium, and then over the quadrigemini muscles to run down near to the bone of the thigh at its back-part, giving off nerves to the neighbouring muscles and teguments. Some way above the ham, where it has the name of the *popliteus* nerve, it sends off a large branch that passes over the fibula, and sinking in among the muscles on the anterior external part of the leg, runs down to the foot, to be lost in the upper part of the larger toes, supplying the neighbouring muscles and teguments every where in its passage. The larger branch of the sciatic, after giving branches to the muscles and teguments about the ham and knee, and sending a large cutaneous nerve down the calf of the leg, to be lost at last on the outside of the foot and upper part of the lesser toes, sinks below the gemellus muscle, and distributes nerves to the muscles on the back of the leg; among which it continues its course, till, passing behind the internal malleolus, and in the internal hollow of the os calcis, it divides into the two plantar nerves: The internal of which is distributed to the toes in the same manner that the radial nerve of the hand serves the concave side of the thumb and fingers; and the external plantar is divided and distributed to the sole of the foot and

and toes, nearly as the ulnar nerve is in the palm of the hand, and in the concave part of the fingers.

Several branches of these nerves, that serve the inferior extremities, pierce through muscles.

By applying what was said of the nerves in general to the particular distribution of the nerves of the inferior extremities, we may see how people with fractured legs, especially where there are splinters, should be subject to convulsive startings of the fractured member:

—Why, upon tying the blood-vessels in an amputation of the leg, the patients should sometimes complain of violent pain in their toes;—why such patients should also be troubled with startings;—why, for a considerable time after the amputation of the diseased limb, when the suppuration is well advanced, they should complain of pain in the sore which occasioned the amputation.

The *fourth*, which, with the two following, is much smaller than the three superior, soon is lost in the *vesica urinaria* and *intestinum rectum*.

The *fifth* comes forward between the extremity of the *os sacrum* and *coccygis*, to be distributed principally to the *levatores ani*.

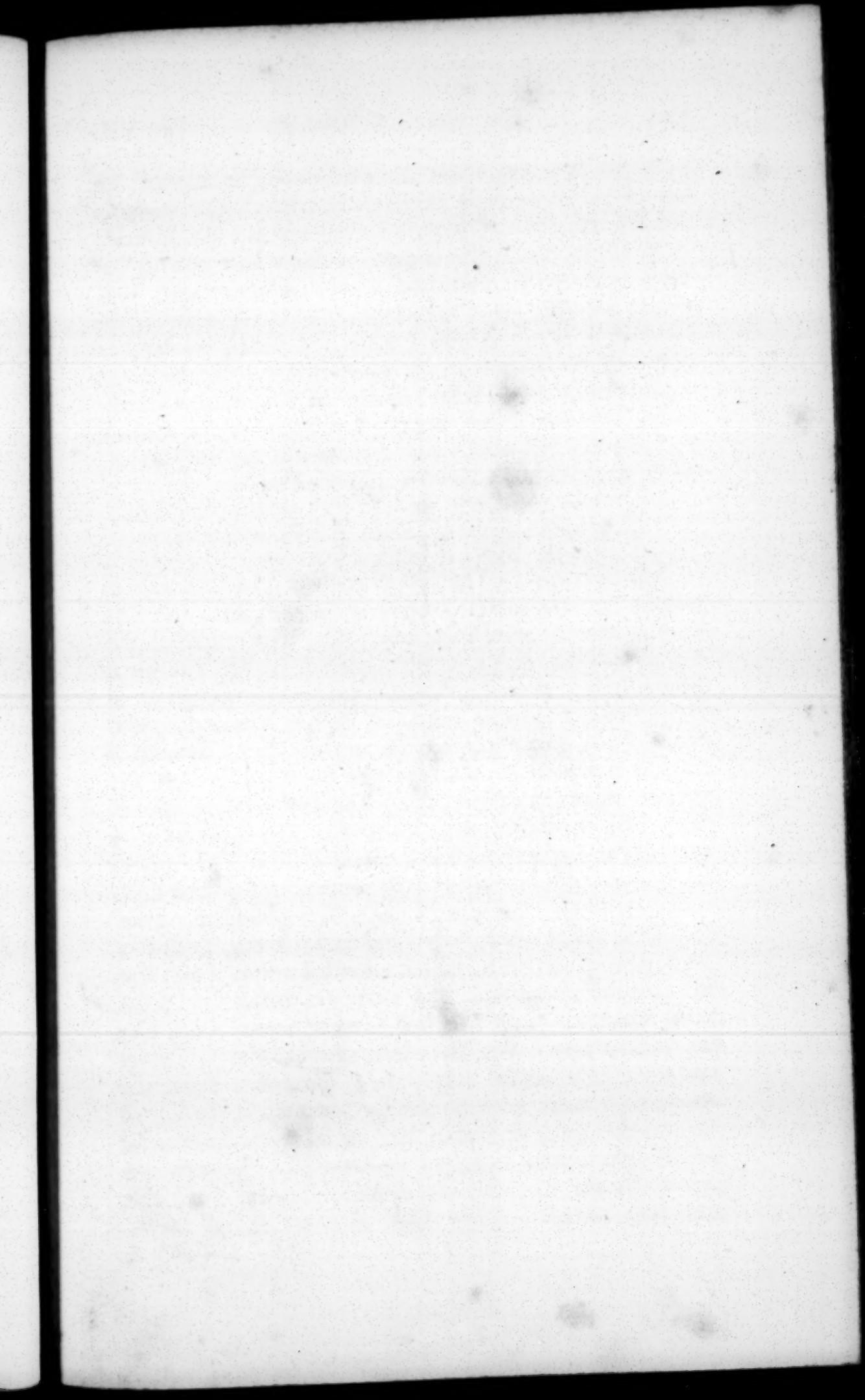
The *sixth*, which may be considered as the termination of a substance called *ligamentum denticulatum*, advances forward below the broad shoulders of the first bone of the *os coccygis*, and is lost in the *sphincter ani* and *teguments* covering it.

The branches of the four last cervical nerves, and of the first dorsal, which are bestowed on the superior extremities, and the two crurals, with the sciatic, which are distributed to the inferior extremities, are much larger proportionally to the parts they serve, than the nerves of the trunk of the body, and especially of the viscera, are; and for a very good reason, that in the most common necessary actions of life, a sufficient quantity of fluid, on which the influence of nerves seems to depend, may be supplied to the muscles there, which are obliged to perform more frequent and violent con-

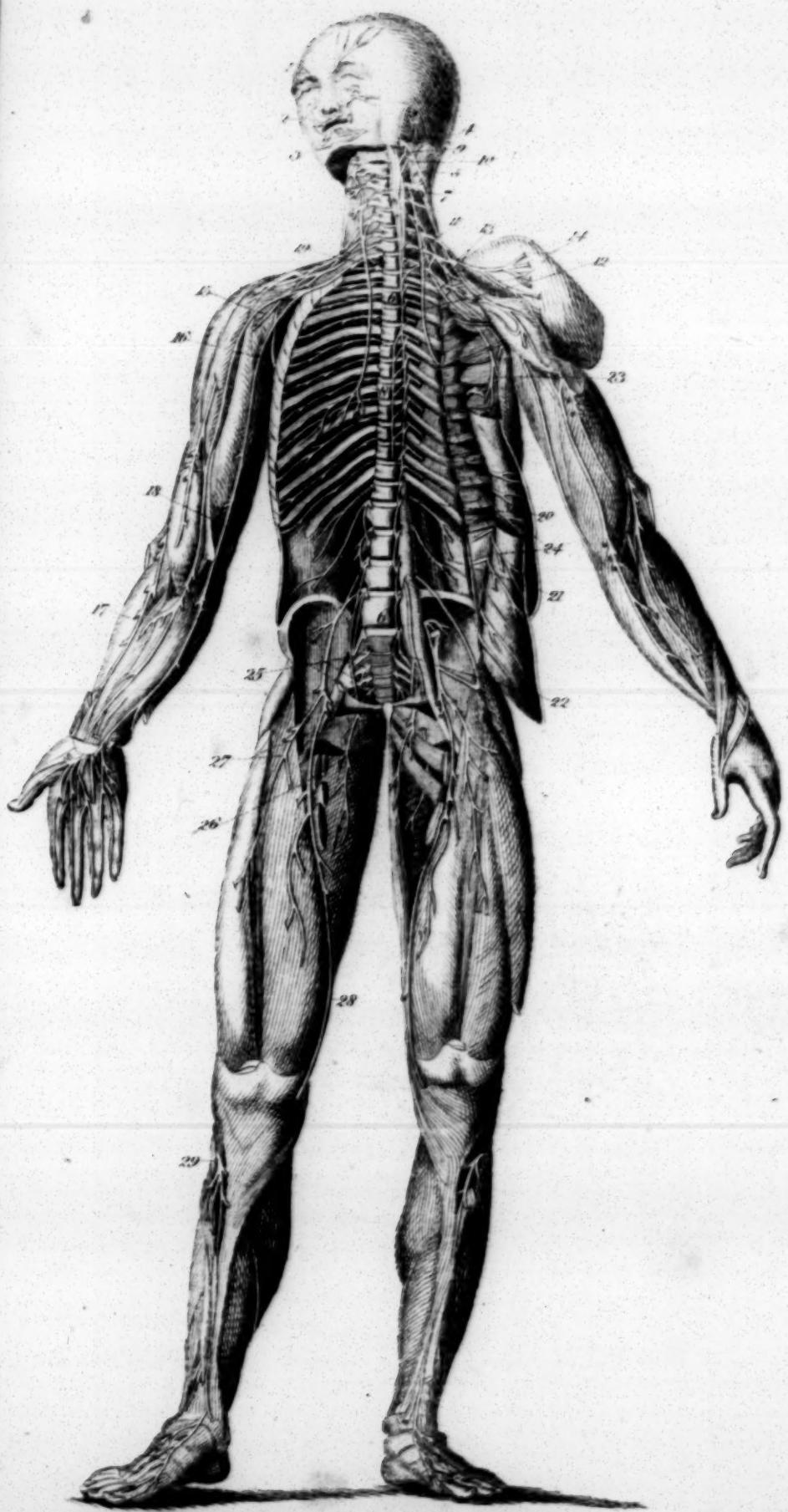
tractions than any other parts do.—The size of the nerves of the inferior extremities seems larger proportionally than in the superior extremities; the inferior extremities having the weight of the whole body to sustain, and that frequently at a great disadvantage.—What the effect is of the nerves here being injured, we see daily: When people happen, by sitting wrong, to compress the sciatic nerve, they are incapable for some time after to support themselves on the affected extremity; and this is still more remarkable in the sciatica or hip-gout, in which the member is not only weakened, but gradually shrivels and wastes.

#### EXPLANATION OF TABLES XV. and XVI.

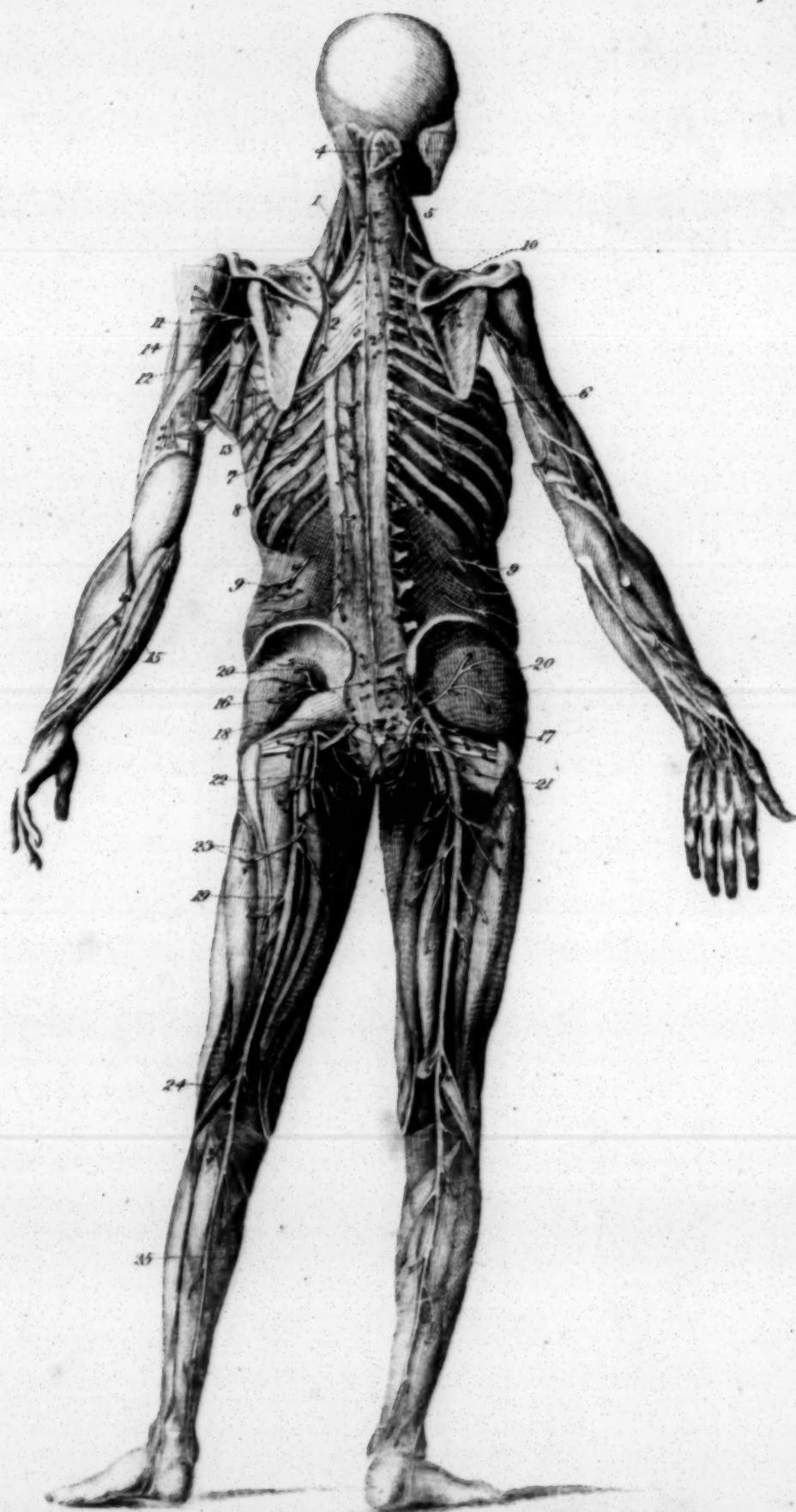
TAB. XV.—(1) The first branch of the fifth pair of nerves. (2) The second branch of the fifth pair. (3) The third branch of the fifth pair. (4) The trunk of the eighth pair cut. (5) The recurrent nerve. (6) The great sympathetic nerve. (7) The uppermost ganglion of the great sympathetic nerve. (8) The ramus splanchnicus of the great sympathetic nerve. (9) A branch of the sub-occipital, or tenth pair of the head, joining the great sympathetic nerve. (10) The first cervical nerve. (11) The seventh cervical nerve. The intermediate cervicals come out in a similar manner. (12) The phrenic nerve. (13) The axillary plexus. (14) The muscular nerve of the arm. (15) The articular nerve. (16) The spiral nerve. (17) The radial nerve. (18) The ulnar nerve. (19) The first intercostal nerve. (20) The last intercostal nerve, The other ten come out in the same manner. (21) The first lumbar nerve. (22) The last lumbar nerve. The three intermediate lumbar nerves come out in a similar way. (23) Branches from the external thoracic nerves running down upon the side of the thorax. (24) Branches sent off from the intercostal and lumbar nerves to supply the outer part of the thorax and abdomen. (25) Nerves of the os sacrum. (26) The obturator nerve. (27) The anterior crural nerve. (28) A



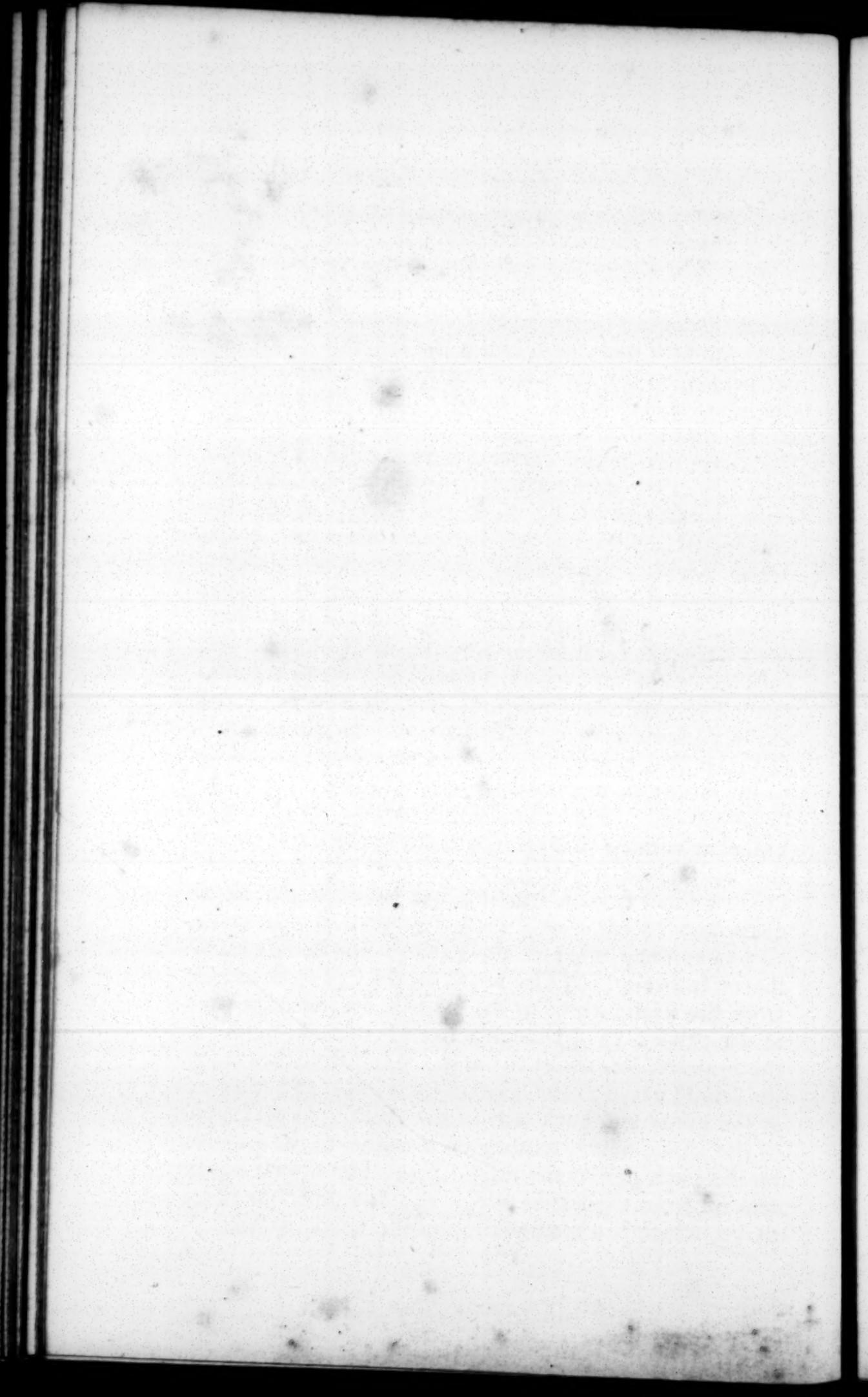
TAB. XV.



T A B. XVI.

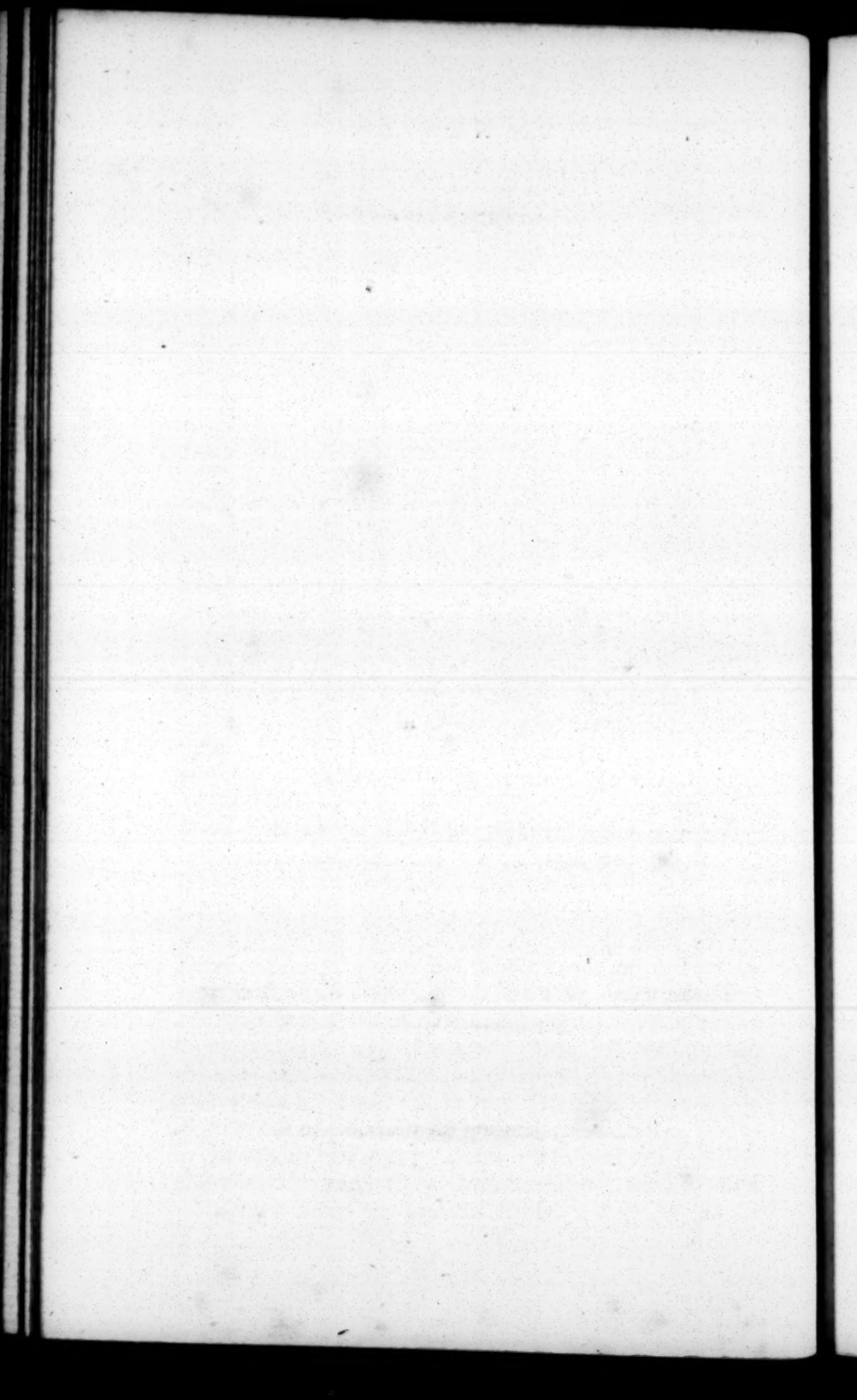


D. Thymotheus



(28) A branch of the anterior crural nerve, which runs near the vena saphena major. (29) The anterior tibial nerve running down to the foot.

TAB. XVI.—(1) The recurrent nerve. (2) A branch of the 4th cervical nerve, joining the recurrent one before it terminates on the *musculus trapezius*. (3) Branches of the fifth pair, perforating the *scalenus medius* to be spent upon the rhomboid muscles. (4) Branches of the sub-occipital nerve, running to the small muscles at the under and back part of the head. (5) Posterior branches of the cervical nerves. (6) Posterior branches of the dorsal nerves. (7) Posterior branches of the dorsal and lumbar nerves running to the erector muscles of the back. (8) Posterior branches of the dorsal nerves, penetrating the intercostal muscles. (9) Branches from the last dorsal, and from the lumbar nerves, supplying the lumbar and abdominal muscles. (10) Branches from some of the lower cervical nerves, running to the muscles on the back part of the scapula. (11) The articular nerve. (12) A branch from the axillary plexus running to the *musculus latissimus dorsi*. (13) Another branch from the axillary plexus running to the *latissimus dorsi* and *serratus magnus*. (14) The spiral nerve. (15) The ulnar nerve. (16) Small branches coming through the holes in the back part of the os sacrum running to the muscles, &c. there. (17) A small branch running out between the os sacrum and os coccygis. (18) The end of the cauda equina running through the canal at the back part of the os sacrum. (19) The sciatic nerve. (20) Branches from the sciatic nerve to the muscles on the back part of the pelvis. (21) Branches from the sciatic nerve to the muscles, &c. about the anus. (22) Branches from the sciatic nerve to the *gluteus maximus* and muscles at the upper and back part of the thigh. (23) Trunk of the sciatic nerve, sending off branches to the muscles on the back part of the thigh. (24) The fibular nerve sent off from the sciatic one. (25) The posterior tibial nerve, which is a continuation of the sciatic nerve.



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A  
T R E A T I S E  
O N  
COMPARATIVE ANATOMY.

BY  
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PUBLISHED BY HIS SON,  
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WITH  
Considerable IMPROVEMENTS and ADDITIONS,  
By other Hands.

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## P R E F A C E.

WHAT is called *Comparative Anatomy*, was certainly the first branch of the science that was cultivated ; and from it the earliest anatomists formed their notions and system of the human body. The natural prejudices of mankind, and, in some sense, common humanity, opposed any attempts to be made in the other way. As the first physicians were philosophers, and this part of natural knowledge more immediately related to medicine, they particularly applied to it. Democritus, who, according to some, was the master of Hippocrates, spent much time in dissecting brutes and examining their several parts. He applied himself with such eagerness to this study, as to incur the censure of madness. His design was to examine the nature of the bile, and learn the seat and causes of diseases. That this science was much improved by the times of Hippocrates, is very apparent from his writings, which are intermixed with reasonings drawn from it ; and some parts of his physiology are only applicable to brutes. These passages appear to us exceeding obscure, often false and contradictory ; and have for that reason been rejected by some very great critics. But is not this owing to our own ignorance ? We do not well understand the then received system of anatomy, and his terms and names do not correspond to ours. The small tract *De Vulneribus Capitis*, is as great a master-piece in its kind as the *Coacæ Predictiones*. Yet the first has been esteemed by some lame and imperfect, and afforded occasion for many disputes and wranglings ; and all this because not understood. Anatomists, however, have done by Hippocrates in most cases as the critics with Homer, made him the master of all human and divine science. Not a new division of a bone, or dispute about a process or articulation, but has been referred to his judgment ; and he has often been made to explain what he never dreamt of. Galen, the father of anatomists, is, for the same reason, in many places, become an obscure writer. He is accused and defended by the greatest succeeding masters. Vesalius, the great restorer of anatomy, will not allow accuracy or truth in many of his descriptions ; they are, according to him, taken from brutes, and obtruded on the world for human.

The other anatomists treat Vesalius much in the same manner ; and, with uncommon sagacity and unwearyed application,

tion, have found out variations and *lufus naturæ* in particular parts, that they may establish Galen's descriptions, and condemn those of Vesalius. This is particularly the case with Eustachius in his Treatise on the Kidneys. How shall we now understand Galen, and judge between these great anatomists? It is Comparative Anatomy alone can extricate us from this confusion; as it will teach us when Galen and others described and reasoned from brutes, and when not. We shall then find, that the greatest part of his descriptions was taken from brutes, which he transferred by analogy to the human body, and so are inaccurate; that a few were taken from the human subject, and are not capable of being otherwise applied. This study he himself recommends with great earnestness to his scholars; and it is observable, that the most eminent anatomists first discovered their genius by an early attachment to it. This was particularly the case of Vesalius and Valsalva\*.

As the first knowledge the ancients gained in anatomy was from the dissection of brutes, so they formed the names and terms of art from the most natural appearance the part afforded, and that in different animals. Those names were applied to the corresponding parts in the human body, and retained by succeeding anatomists to avoid a multiplicity of words. This, however, produces one bad effect, that it must mislead us in our conceptions, as those names are often very improper epithets in the human subject. The author has elegantly remarked several of these. The name of *right* and *left* ventricle is apt to give a wrong idea of the position of the heart; and the *aorta ascendens* and *descendens* has imposed on some of the masters in anatomy, who, it is plain, have taken their figures from the name. Disputes have arisen about the *appendix vermiformis*, &c. which are all cleared up when we once view the part in the animal whence the name was taken.

The intention of nature in the formation of the different parts, can no where be so well learned as from this science; that is, if we would understand physiology, and reason on the functions in the animal-œconomy, we must see how the same end is brought about in other species. We must contemplate the part or organ in different animals, its shape, position, connection with the other parts, &c. and observe what thence arises.

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\* Gaudebat enim avicularum, aliorumque animalium dissectionibus; etrumque extra curiosus. quam pro illa ætate, rimabatur: quam ego præsignificationem, non in Vesilio tantum, sed in aliis quoque pueris fuisse scio, qui, cum adolevissent, anatomiae penitus se dederunt. *Morgagni Comment. de vita Valsalvae.*

rises. If we find one common effect constantly produced, tho' in a very different way, then we may safely conclude that this is the use or function of the part: this reasoning can never betray us, if we are but sure of the facts. The writers in physiology have generally taken another route, and one favourite thesis or other serves to explain the whole or most of the system. An innate and concocting heat, acids, menstruums, &c. have all had their successive reigns and patrons: and in truth, physicians seem not to have sufficiently considered the importance of this study to form a complete physiology, which must ever be the great basis of their art. They have bestowed pains in examining the human body, dissected minutely its several parts, traced out (perhaps often invented) a new division of a muscle: But how little has physic been promoted by all this? The most accurate description of the human stomach, with all its veins, arteries, nerves, &c. will never rightly explain digestion. What must we then do? Examine it in the other species of animals, mark there its differences and the effects, compare these with the human; and then shall we, in some measure, be able to judge what are the principal instruments, and how they are employed in this compound action. Any other way of reasoning (as the author well observes) will never bring us to the solution of a philosophical or medical problem. It must indeed be confessed, that this method is tedious and slow; many observations must first be made, and the labour of searching and examining gone through, before we can have proper materials to build on. Yet these are the hard conditions on which the knowledge of natural causes is to be obtained; which, as a great genius says, *Tam facile solertia vinci possunt, quam solent conatibus vulgaribus difficuler cedere.*

Of this kind of reasoning we have many beautiful instances in the following papers. Such is the account of the position of the Duodenum; of the cause of our preferring the Right Arm; of the circulation of the blood in the Foetus; the history of the Thymus and Thyreoid Glands, their use and mutual proportion; the use of the Spleen, &c. This last he explains in so short and masterly a manner, that more argument will be found in the few lines upon it, than is to be collected from whole treatises on the subject. But as his design was to give a description of the several species, or rather their principal differences, he chiefly confines himself to this. So in the anatomy of the dog he compares the different position, shape,

shape, length, &c. of the several parts with the corresponding parts in man ; and from that one circumstance, the difference of an erect and horizontal posture, explains all the variations. This reasoning then gives solution to many difficulties in the human anatomy ; why the Spleen is so firmly attached to the Diaphragm ; why the Omentum reaches only so far ; why the posterior part of the Bladder is only covered by the Peritoneum, &c. There have been disputes about the fissure in the human liver, and different accounts given. These all vanish, when we consider this viscus in different animals. We then find, that there are more or fewer divisions, according to the greater or lesser flexibility of the spine. The same rule holds with regard to the divisions of the lungs. This reasoning likewise excludes the pretended use of the ligament in the human liver. And, in short, we can understand but little of our own structure unless we study that of other animals : we shall then find, that the several variations are relative, and depend on the different way of life ; that is, one leading specialty draws after it a great many more, in which nature is always an œconomist, and takes the shortest route.

The beautiful gradation of nature in the different orders of beings is very remarkable, and strikes the mind first as being most obvious ; but when we take any one species, the case there is still the same, and we observe as surprising a difference. Thus, in the animal kingdom, some are provided with lungs, when others are deprived of these breathing organs ; some have a muscular diaphragm and strong abdominal muscles, others a mere membrane. It must be very entertaining to learn how these differences and deficiencies are adjusted and supplied : it is then from this science alone we can understand that simplicity of nature which is so much talked of, and but little understood. Hence likewise we must learn what to think of animals perfect and imperfect.

Anatomists have made a noise about the different structures of the same part in the human body, and been at great pains to make collections of those *Lufus Naturæ*, as they call them ; which because they are rare, are for that very reason of no great consequence to be known. The epithet, however, is extremely proper ; for the most remarkable of them are transitions from the order or law of nature that obtains in one species to that of another. Thus it has been observed, (though very rarely), that the liver was situated in the left hypochondrium : but, as our author remarks, it is not peculiar to it to

lie

lie on the right side in animals ; for in fowls it lies equally in both, and in fishes mostly on the left.

It is surprising that we have no tolerable treatise on this subject, which is in itself so entertaining and so conducive to promote Medicine. Those who have made attempts this way, have only collected and ranged in order some particular species, such as Birds or Fishes. They have likewise with great labour given us figures and descriptions of them ; but all this is little else than mere amusement. It is the structure of their internal organs we seek after, and the manner how the different functions of the animal-œconomy are performed. Their histories of these are every way defective and erroneous. There are indeed noble hints to be found in the writings of some of our modern anatomists, particularly those of the immortal Dr Harvey. That great man well understood the importance of this science to advance medicine ; and accordingly employed the most of his time in dissecting animals of different tribes, and making experiments on them : by which means he made the greatest discovery that ever was in the science, and laid the foundation of the present system. He had certainly left us other treatises on this subject, had he not been interrupted by the civil wars. The physicians who lived then, imitating his example, made many new experiments on the bodies of brutes, changing their juices by transfusing of new liquors, accurately marking the effects, &c. that all this might be transferred to the human body: And indeed, from the application of these reasonings to the observations they made on morbid bodies, the science seemed fast advancing to that physical certainty which can be attained from experiment and observation. But, alas ! this spirit died with those great men, and theory and calculation came in its place. Mathematics, it was said, could alone bring the science to certainty, and throw out conjecture. The quantity and velocity of the blood, the force of the heart, diameters of the vessels, &c. were subjected to measure and number, and diseases next were to be accounted for, all in a mathematical manner.—This method, however, did not succeed according to wish : For, first, those great geniuses disagreed widely in their calculations, and differed from one another ; whence, in place of certain conclusions, we had only wranglings and disputes : not to mention, that some of them made such estimates as must plainly appear ridiculous at first sight\*. This, some may say,

proves

\* The ingenious Dr Pitcairn was the chief man in these parts who gave into

proves nothing ; it was the fault of the artists, who assumed wrong hypotheses for their calculations, or were not perhaps accurate enough in their observations. True; but whose fault was it to adapt figure and number to a subject which refuses them, through its numberless deviations from fixed laws and conditions ?—Is an animate body a mere bundle of hard conical elastic tubes, and the heart a pump forcing the liquors through ? Are then all the vessels exact cones, or have two anatomists agreed in their measures of them ? Do they not yield every way ? and are they not continually obstructed in different places ? Are there not many different attractions prevailing for the several secretions, and many different forces acting on the vessels at the same time, which can never be determined ? &c. These and such like considerations will soon convince us how little the practice of medicine is to be promoted by those speculations \*. If these gentlemen meant by mathematical reasoning physical experiments, then no one ever doubted of this, no more than they do of the use of mathematics in natural philosophy itself. But as this seems not to be their sense of the matter, they should point out a few diseases which this science has explained, and wherein it has corrected the received practice.—But we are now got from the subject to what is foreign. To return then : Comparative Anatomy has hitherto been treated but by pieces. Thus some, writing on the human eye, have examined the eyes of other animals ; and so with regard to the heart, &c. Some have given us the description of one particular animal, others of another. But no one author, that we know of, has given us a system of this science, where we might have a summary

view

into this way. He supposes the force of the muscles to be in a compound ratio of their length, breadth, and depth ; that is, as they are homogeneous solids in the ratio of their weights. Whence knowing the force of any one muscle, we can by the rule of Proportion (from their weights) determine that of another. This he applies to the stomach ; and by the computation, its muscular force at least is equal to 117,088 lb. weight.—That muscles are in that proportion, is a mere hypothesis, for which the Doctor does not offer the smallest proof ; and had he assigned five ounces as the weight of the stomach, he had been nearer the truth. This is one glaring instance how much theory and whim may prevail with the greatest of men over common sense.

\* The authority of Hippocrates is often adduced in this argument ; for which they cite two passages. In the one he recommends the study of Astronomy as necessary to a physician ; and in the other, that of Arithmetic and Geometry. —The first he did from his belief in the influence of the stars ; and the second from his veneration for the Pythagoric numbers, in the mysteries of which he founded his theory of the crises in acute diseases : Both these considerations then are foreign to the purpose, nor is there in any of his genuine writings the smallest vestige of this kind of reasoning. On the contrary, Celsus says of him,

*Primus ab studio sapientiae medicinam separavit.*

view of the most material differences in the structure of animals. There are indeed compends of this science, if you will, which are esteemed by many, and were wrote with the noble design of illustrating the wisdom and goodness of our Maker. But those who composed them were not anatomists themselves; so could only collect from others, which they often do without any judgment: for how voluminous foever their works may be, yet if you will strip them of their repeated exclamations, citations of authors and books, the many strange and surprising stories, all told, however, by creditable vouchers, you will have little left behind besides an indigested chaos of histories and descriptions, some true and many false. The argument, however, was popular, and they could not fail of pleasing.

The following Treatise, by the late celebrated Dr Monro, is executed upon a more useful plan, and in a more systematic manner. The descriptions are all taken from the life, and the reasoning employed is plain and conclusive. These are intermixed with many practical observations in medicine and surgery, which must equally instruct and entertain the reader.

This work, in substance, appeared about forty years ago, under the title of *An Essay on Comparative Anatomy*; but without any author's name, being only composed from Notes taken by a student at the Clas Lectures. As it was of course exceedingly defective and erroneous, the present Professor of Anatomy, in preparing for the press the Collection of his father's Works lately published, corrected this piece amongst the rest; and also made some additions to it, from observations that had been collected by the author with a view to a larger work upon the subject, but which various avocations prevented him from prosecuting. The Professor's design, however, being only to correct his father's works, not to enlarge them by additions of his own, the present performance still remained less complete than might be wished, and unimproved by later discoveries. It having been, therefore, suggested to the present publisher, as proprietor of the late Doctor's Works, that a separate Edition of this Treatise, improved and enlarged, could not fail of being acceptable, he readily adopted the design; and was fortunate enough to prevail with some gentlemen versed in the subject to undertake the task of making the necessary additions and improvements. This has been accordingly accomplished, as far as the limits of a compend would admit, or as seemed to comport with the original scale of the

the undertaking. Some of the principal subjects, particularly the Dog, Fowls, and Fishes, have received considerable augmentation: Others have been entirely added; as Amphibious Animals, Serpents, Insects, &c.: And lesser additions in great number have been made in various parts of the work,—either inserted into the body, or thrown to the bottom of the page in the form of notes. Of the additions in general, a few are drawn from the experience and observation of the gentlemen themselves who had the care of the edition, some from different parts of the late Author's others Works, and the greatest number from the Lectures of the illustrious Professor who now fills the Anatomical Chair.

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**COMPARATIVE ANATOMY.**

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**THE INTRODUCTION.**

THE principal advantages of Comparative Anatomy are the following: First, It furnishes us with a sufficient knowledge of the different parts of animals, to prevent our being imposed upon by such authors as have delineated and described several parts from brutes as belonging to the human body. Secondly, It helps us to understand several passages in the ancient writers in medicine, who have taken many of their descriptions from brutes, and reasoned from them: their reasonings have often been misapplied (and consequently wrong explained) by the moderns, through a foolish fondness to support their own inventions, or give an air of antiquity to a favourite hypothesis. The third and great use we reap from this science, is the light it casts on several functions in the human œconomy, about which there have been so many disputes among

mong anatomists: These will be in a great measure cleared up by exhibiting the structure of the same parts in different animals, and comparing the several organs employed in performing the same action, which in the human body is brought about by one more complex.

In this view, it is altogether needless to insist on those parts whose use is easily understood when once their structure is unravelled. Thus, for instance, if we be acquainted with the action of the muscles in general, it will not be difficult to determine the use of any particular muscle whose origin and insertion is known, if we at the same time consider the various connections of the bones to which it is fixed, and the different degrees of mobility they have respect to each other. In the same manner, if we know the use of the nerves in general, we can easily assign the use of those nerves which are distributed to any particular part. There is then no occasion for a complete Osteology, Myology, &c. of the several animals we shall treat of; nor need we trouble ourselves about the structure of any of the parts, unless when it serves to illustrate some of the fore-mentioned purposes \*.

That the first use we proposed from examining the structure of the parts in brutes is real and of consequence, is evident from looking into the works of some of the earliest and greatest masters of anatomy, who, for want of human subjects, have often borrowed their descriptions from other animals. The great Vesalius, although he justly reproves Galen for this fault, is guilty of the same himself, as is plain from his delineations of the kidneys, uterus, the muscles of the eye, and some other

\* Notwithstanding this assertion of the learned author, we must observe, that the myology of animals seems exceedingly necessary for young anatomists, who generally begin with dissecting them before they have access to human bodies. For this reason, we have added, not indeed a complete myology, but an account of the particulars wherein the muscles of a dog differ from those of a man; this being the animal most frequently chosen for dissections, and one of those whose structure bears no small resemblance to that of the human species.

other parts. Nor is antiquity only to be charged with this; since, in Willis's *Anatomia Cerebri* (the plates of which were revised by that accurate anatomist Dr Lower), there are several of the pictures taken from different brutes, especially the dog, besides those he owns to be such.

We shall give several examples of the second use in the sequel of the work.

The animal kingdom, as well as the vegetable, contains the most surprising variety; and the descent in each is so gradual, that the little transitions and deviations are almost imperceptible. The bat and flying-squirrel, though quadrupeds, have wings to buoy themselves up in the air. Some birds inhabit the waters; and there are fishes that have wings, and are not strangers to the airy regions; the amphibious animals blend the terrestrial and aquatic together.

The animal and vegetable kingdoms are likewise so nearly connected, that if you take the highest of the one, and the lowest of the other, there will scarce be perceived any difference. For instance, what difference is there betwixt an oyster, one of the most inorganised of the animal tribe, and the sensitive plant, the most exalted of the vegetable kingdom? They both remain fixed to one spot, where they receive their nourishment, having no proper motion of their own, save the shrinking from the approach of external injuries. Thus we observe a surprising chain in nature.

As there is then such a vast variety, it is not only needless, but impossible, to consider all of them particularly. We shall take only some of the most remarkable genera; and hope, from what will be said of them, any of the intermediate degrees may be understood.

In treating of Quadrupeds, we shall divide them into the carnivorous and herbivorous. As an instance of these last, we shall take the ruminant kind. The Fowls we shall divide into those that feed on grain, and

and those that feed on flesh. The distinction we shall make in treating of Fishes, shall be of those that have lungs, and those that have them not. The first indeed are with difficulty procured, and at the same time differ very little from quadrupeds.

As the structure of insects and worms is so very minute, and lends us but little assistance for the ends proposed, we purposely omit them\*.

In inquiring into the structure of different animals, we ought to be previously acquainted with the form of their body, manner of life, kind of food, or in short with their natural history; which will lead us to account for the reason of their different structure, and thence explain the actions of the human body.

\* Though the anatomy of insects is very difficult, and little known, yet as they constitute one of the great classes into which animals are divided, and as many of them are very useful to man, we have thought proper to add a few circumstances concerning them, which at least may be considered as matters of curiosity highly worthy of the attention of every anatomist; not to mention, that every advance in knowledge, with respect to the structure of any one animal, must either directly or indirectly cast some light on the structure of some part of every other.

## OF QUADRUPEDS in general.

ALL quadrupeds have a covering of hair, wool, &c. to defend them from the injuries of the weather; which varies in thickness according to the season of the year, and difference of the climate. Thus in Russia and the northern countries, the furs are very thick and warm; while the little Spanish lap-dogs, and Barbary cows, have little or no hair at all.

The *cutis* and *cuticula* in quadrupeds are disposed much in the same way as the human, only more elastic. Immediately under this there is a very thin cutaneous muscular substance, called *panniculus carnosus*, which is common to all quadrupeds, the porcine kind excepted; this principally covers the trunk, serving to shrivel the skin, in order to drive off insects, their tails and heads not being sufficient for this purpose, while their extremities are employed in their support and progression.

It has probably been from observing some muscles of the human body, such as the *platysma myoides*, *cremaster*, and *frontales*, and the collapsed *tunica cellulosa* of emaciated subjects, to resemble this thin muscle, that some of the older anatomists reckoned such a *panniculus* among the common teguments of the human body. This Carolus Stephanus has well observed.

Most part of quadrupeds want clavicles, whereby their anterior extremities fall upon their chest, so as to make their thorax proportionally narrower than the human. This small distance of their anterior extremities is very necessary for their uniform progression: Apes indeed, and squirrels, have clavicles, to allow them a more full use of their extremities in climbing; but when they walk on all fours, they walk but indifferently.

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## The ANATOMY of a D O G.

WE may first observe of this animal, as indeed of most quadrupeds, that its legs are much shorter in proportion to its trunk than in man, the length of whose steps depends entirely on the length of his inferior extremities: however, to balance this, the trunk of the animal is proportionally longer and smaller, and his spine more flexible, by which he is able at each step to bring his posterior extremities nearer to his anterior. His common teguments are much a-kin to those of other quadrupeds; only they allow little or no passage for sweat; but when he is over-heated, the noxious and superfluous matter finds an exit by the salivary glands; for he lolls out his tongue, and slavers plentifully\*.

The pyramidal muscles are wanting; to supply which, the rectus is inserted fleshy into the os pubis.

The *omentum* reaches down to the os pubis; which, considering the posture of the animal, we will find to be a wise provision, since its use is to separate an oily liquor for lubricating the guts, and facilitating their peristaltic motion. So in our erect posture, the natural gravity of the oil will determine it downward; but in the horizontal position of these creatures, if all the intestines were not covered, there would be no favourable derivation of the fluid to the guts lying in the posterior part of the abdomen, which is the highest;

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and

\* We are not, however, to suppose, that because a dog does not sweat, he has no insensible perspiration. That a dog perspires is evident, because one of these animals can trace another by the scent of his footsteps; which could not happen, if a large quantity of perspirable matter was not constantly going off. We may also observe, that the disease called *Rabies Canina*, is peculiar to dogs, foxes, wolves, and others of that genus; for though the bite of other mad animals, such as cats, or hogs, and even poultry, will produce the disease, no fair instance has ever been brought of any of those being originally seized with this malady.

and besides, had the omentum reached much farther down in us, it would not only have supplied too great a quantity of oil to the lower part of the abdomen, but we would have been in continual danger of herniæ; and even at present the omentum frequently passes down with some of the other viscera, and forms part of these tumours. To these, however, the dog is not subject, as his viscera do not press so much on the rings of the abdominal muscles, and besides are prevented from passing through by a pendulous flap of fat, mentioned p 358. The inferior and anterior lamella of the omentum is fixed to the spleen, fundus of the stomach, pylorus, liver, &c. in the same way as the human; but the superior having no colon to pass over, goes directly to the back-bone. This serves to explain the formation of the small omentum in the human body; which is nothing but the large omentum, having lost its fat, passing over the stomach and colon, where it reassumes its pinguedo, so proceeds, and is firmly attached to the liver, spine, &c. The striae of fat are pretty regularly disposed through it, accompanying the distribution of the blood-vessels to guard them from the pressure of the superincumbent viscera.

This animal's stomach, though pretty much resembling the human in its shape, is somewhat differently situated. It lies more longitudinal, as indeed all the other viscera do to accommodate themselves to the shape of the cavity in which they are contained; that is, its inferior orifice is much farther down with respect to the superior than the human: by this means the gross food has an easier passage into the duodenum. Again, the fundus of the human stomach, when distended, stands almost directly forwards, which is occasioned by the little omentum tying it so close down to the back-bone, &c. at its two orifices; but it not being fixed in that manner in the dog, the fundus remains always posterior: this also answers very well the shape of the different cavities, the distance betwixt the cardia

cardia and fundus being greater than that betwixt the two sides. It seems to be much larger in proportion to the bulk of the animal than the human, that it might contain a greater quantity of food at once; which was very necessary, since this animal cannot at any time get its sustenance as men do. The turbillion is not so large, nor is there any coarction forming the *antrum Willefii* as in the stomach of man. It is considerably thicker and more muscular than ours, for breaking the cohesion of their food, which they swallow without sufficient chewing. Hence it is evident the force of the stomach is not so great as some would have it, nor its contraction so violent: otherwise that of dogs would be undoubtedly wounded by the sharp bones, &c. they always take down; for the contraction here is still greater than in the human stomach, which is much thinner. The rugæ of the tunica villosa are neither so large, nor situated transversely, as in the human, but go from one orifice to the other: the reason of which difference is, perhaps, that they might be in less danger of being hurt by the hard substances this creature frequently feeds upon; and for the same reason there is not the like coarction at their pylorus.

The intestines of this animal are proportionally much shorter than ours; for the food which these creatures mostly use, soon dissolves, and then putrifies; on which account there was no occasion for a long tract of intestines, but on the contrary that it should be quickly thrown out of the body. The same is to be observed of all the carnivorous animals. The muscular coat of the intestines is also thicker and stronger than the human, to protrude the contents quickly and accurately.

The valvulae conniventes are less numerous, and in a longitudinal direction; and the whole tract of the alimentary canal is covered with a slime, which lubri-

cates the intestines, saves them from the acrimony of the excrementitious part, and facilitates its passage.

The *duodenum* differs considerably in its situation from the human. For in man it first mounts from the pylorus upwards, backwards, and to the right-side; then passes down by the gall-bladder; and, marching over the right kidney and superior part of the psoas muscles, makes a curvature upwards; and passes over the back-bone and *vena cava inferior*, to the left hypochondrium, where it gets through the omentum, mesentery, and mesocolon, to commence *jejunum*, being firmly tied down all the way, the biliary and pancreatic ducts entering at its most depending part: Whereas, in the dog, the duodenum is fixed at the pylorus to the concave surface of the liver, and hangs loose and pendulous with the mesentery backwards into the cavity of the abdomen; then turning up again, is fixed to the back-bone, where it ends in the jejunum; the bile and pancreatic juice are poured into it at the most depending part. Therefore the same intention seems to have been had in view in the formation of this part in both, viz. the giving the chyle, after the liquors of the liver and pancreas are poured into it, a disadvantageous course, that so it might be the more intimately blended with the humours before its entry into the jejunum, where the lacteals are very numerous: And thus, by reason of their different posture, the same design (tho' by a very different order of the parts) is brought about in both.

The other small guts are much the same with ours, only shorter. The great guts are also shorter and less capacious than in the human body; and we take it for a general rule, that all animals that live on vegetable food, have not only their small guts considerably longer, but also their great guts more capacious, than such creatures as feed on other animals. Hence man, from this form of his intestines, and that of the teeth, seems to have been originally designed for feeding on vegetables

tables chiefly ; and still the most of his food, and all his drink, is of that class.

The reason of this difference seems to be, that as animal-food is not only much more easily reduced into chyle, but also more prone to putrefaction, too long a remora of the juices might occasion the worst consequences. So it was necessary that their receptacles should not be too capacious ; but on the contrary, being short and narrow, might conduce to the seasonable discharge of their contents. Whereas vegetable food being more difficultly dissolved and converted into an animal nature, there was a necessity for such creatures as fed on it to be provided with a long intestinal canal, that this food in its passage might be considerably retarded, and have time to change its indoles into one more agreeable to our nature. Besides which there is another advantage which accrues to man in particular, from having his great guts very capacious : for as he is a rational being, and mostly employed in the functions of social life, it would have been very inconvenient as well as unbecoming for him to be too frequently employed in such ignoble exercises ; so that, having this large reservoir for his fæces alvinæ, he can retain them for a considerable time without any trouble.

The *appendix vermiciformis* justly enough deserves the name of an *intestinum cæcum* in this subject, though in the human body it does not ; and it has probably been from the largeness of this part in this and some other animals, that the oldest anatomists came to reckon that small appendicle in man as one of the great guts. On its internal surface we observe a great number of mucous glands \*.

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\* As all these throw out slime, their principal office would seem to be the procuring a sufficient quantity of that matter for the purposes above-mentioned. Still, however, there seems to be some unknown use for this organ in other animals ; for the *appendicula vermiciformis* in them is either of great size or of great length. In

The *colon* has no longitudinal ligaments ; and consequently this gut is not pursed up into different bags or cells as the human : nor does this intestine make any circular turn round the abdomen ; but passes directly across it to the top of the os sacrum, where it gets the name of *rectum*.

At the extremity of the *intestinum rectum*, or verge of the anus, there are found two bags or pouches, which contain a most abominable fetid mucus of a yellow colour, for which I know no use, unless it serves to lubricate the strained extremity of the rectum, and defend it against the asperity of the fæces, or to separate some liquor that might otherwise prove hurtful to their bodies. There is nothing analogous to those sacs in the human subject, unless we reckon the mucilaginous glands that are found most frequent and largest about the lower part of the rectum.

The *mesentery* is considerably longer than in the human body ; that, in his horizontal situation, the intestines may rest securely on the soft cushion of the abdominal muscles. The fat is here disposed in the same way, and for the same reason, as in the omentum. The interstices betwixt the fat are filled with a fine membrane. Instead of a great number of glandulæ vagæ to be found in the human mesentery, we find the glands few in number, and those are closely connected together ; or there is only one large gland to be observed in the middle of the mesentery of a dog, which, from its imagined resemblance to the pancreas and the name of its discoverers, is called *pancreas Asellii* ; but the resemblance, if there is any, depends chiefly on the connection, the structure being entirely different. The reason why this in man is as it were subdivided into

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a rat, it is rather larger than the stomach ; in others, as swine, and some of the animals which live on vegetables, it has long convolutions, so that the food must be lodged in it for a long time. Thus, probably, some change takes place in the food, which requires a considerable time to effectuate, and, though unknown to us, may answer very useful purposes to the animal.

many smaller ones, may possibly be, that as the guts of a human body are proportionally much longer than those of this creature, it would have been inconvenient to have gathered all the *lactea primi generis* into one place ; whereas, by collecting a few of these vessels into a neighbouring gland, the same effect is procured much more easily. Whether the food in this animal needs less preparation in its passage through these glands, is a matter very much unknown to us ; though it is certain that some changes really do take place.

The *pancreas* in man lies across the abdomen, tied down by the peritonæum ; but the capacity of this creature's abdomen not allowing of that situation, it is disposed more longitudinally, being tied to the duodenum, which it accompanies for some way. Its duct enters the duodenum about an inch and half below the *ductus communis*.

The *spleen* of this animal differs from ours very much, both in figure and situation. It is much more oblong and thin, and lies more according to the length of the abdomen, like the *pancreas*. Though the spleen of this creature is not firmly tied to the diaphragm (which was necessary in our erect posture to hinder it from falling downwards), yet by the animal's prone position, its posterior parts being rather higher than the anterior, it comes to be always contiguous to this muscle, and is as effectually subjected to an alternate pressure from its action as the human spleen is.

The human *liver* has no fissures or divisions, unless you please to reckon that small one betwixt the two *pylæ*, where the large vessels enter : Whereas in a dog, and all other creatures that have a large flexion in their spine, as lions, leopards, cats, &c. the liver and lungs are divided into a great many lobes by deep sections, reaching the large blood-vessels, which in great motions of the back-bone may easily shuffle over one another ; and so are in much less danger of being torn or bruised, than if they were formed of one entire piece, as

we

we really see it is in horses, cows, and such creatures as have their back-bone stiff and immovable. There is here no *ligamentum latum* connecting the liver to the diaphragm, which in our situation was necessary to keep the viscera in its place: Whereas in this creature, it naturally gravitates forwards, and by the horizontal position of the animal is in no danger of pressing against the vena cava; the preventing of which is one use generally assigned to this ligament in man. Had the liver of the dog been thus connected to the diaphragm, the respiration must necessarily have suffered; for, as we shall see afterwards, this muscle is here moveable at the centre as well as at the sides: But in man the liver is fixed to the diaphragm, mostly at its tendinous part; that is, where the pericardium is fixed to it on the other side; so that it is in no danger of impeding the respiration, being suspended by the mediastinum and bones of the thorax. In consequence of this viscera being divided into so many lobes, it follows, that the hepatic ducts cannot possibly join into one common trunk till they are quite out of the substance of the liver; because a branch comes out from every lobe of the liver; all of which, by their union, form the hepatic duct: whence we are led to conclude, that the hepato-cystic ducts, mentioned by former authors, do not exist. The gall-bladder itself is wanting in several animals, such as the deer, the horse, the ass, &c.; but in place of it, in such animals, the hepatic duct, at its beginning, is widened into a reservoir of considerable size, which may answer the same purpose in them that the gall-bladder does in others.

We come next, after having examined the chylopoietic viscera, to discourse of those organs that serve for the secretion and excretion of urine. And first of the kidneys: Which in this animal are situated much in the same way as in the human subject; but have no fat on their inferior surface, where they face the abdomen, and are of a more globular form than the hu-

man. The reason of these differences will easily appear, if you compare their situation and posture in this animal with those in a man who walks erect. They are placed in this subject in the inferior part of the body, so are not subject to the pressure of the viscera, which seems to be the principal cause of the fatness of those organs in us, and perhaps may likewise be the cause of our being more subject to the stone than other animals. Hence there is no need of any cellular substance to ward off this pressure where there would necessarily be fat collected; but the superior part of their kidneys is pretty well covered with fat, lest they should suffer any compression from the action of the ribs and spine.

In the internal structure there is still a more considerable difference: For the *papillæ* do not here send out single the several *tubuli uriniferi*; but being all united, they hang down in form of a loose pendulous flap in the middle of the pelvis, and form a kind of septum medium; so that a dog has a pelvis formed within the substance of the kidney. The only thing that is properly analogous to a pelvis in man is that sac or dilatation of the ureters formed at the union of the *ductus uriniferi*. The external part of the kidney of a dog somewhat resembles one of the lobes of the kidney of a human foetus: but in a human adult the appearance is very different; because, in man, from the continual pressure of the surrounding viscera, the lobes, which in the foetus are quite distinct and separated, concrete, but the original cortical substance is still preserved in the internal parts of the kidney. The reason of these particularities may probably be, that the liquors of this animal, as of all those of the carnivorous kind, being much more acrid than those that live on vegetable food, its urine must incline much to an alkaliscency, as indeed the smell and taste of that liquor in dogs, cats, leopards, &c. evidently show, being fetid and pungent, and therefore not convenient to be long

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retained in the body. For this end it was proper, that the secerning organs should have as little impediment as possible by pressure, &c. in the performing their functions; and for that design, the mechanism of their kidneys seems to be excellently adapted: We have most elegant pictures in Eustachius of the kidneys of brutes, delineated as such, with a view to shew Vesalius's error in painting and describing them for the human.

The *glandulae* or *capsulae atrabiliariae* are thicker and rounder than the human, for the same reason as the kidneys.

The *ureters* are more muscular than the human, because of the unfavourable passage the urine has thro' them; they enter the bladder near its fundus.

The bladder of urine differs considerably from the human; and first in its form, which is pretty much pyramidal or pyriform. This shape of the dog's bladder is likewise common to all quadrupeds, except the ape and those of an erect posture. In men it is by no means pyriform, but has a large sac at its posterior and inferior part: this form depends entirely on the urine gravitating in our erect posture to its bottom, which it will endeavour to protrude; but as it cannot yield before, being contiguous to the os pubis, it will naturally stretch out where there is the least resistance, that is, at the posterior and lateral parts; and were it not for this sac, we could not so readily come at the bladder to extract the stone either by the lesser or lateral operation of lithotomy. Most anatomists have delineated this wrong: so much, that I know of none who have justly painted it, excepting Mr Cowper in his *Myotomia*, and Mr Butty. It has certainly been from observing it in brutes and young children, that they have been led into this mistake. The same cause, viz. the gravity of the urine, makes the bladder of a different form in brutes: In their horizontal position the cervix, from which the urethra is continued, is higher than its fundus;

dus ; the urine must therefore distend and dilate the most depending part by its weight.

As to its *connection*, it is fastened to the abdominal muscles by a process of the peritoneum, and that membrane is extended quite over it ; whereas in us its superior and posterior parts are only covered by it : hence in man alone the high operation of lithotomy can be performed without hazard of opening the cavity of the abdomen. Had the peritoneum been spread over the bladder in its whole extent, the weight of the viscera in our erect posture would have so bore upon it, that they would not have allowed any considerable quantity of urine to be collected there ; but we must have been obliged to discharge its contents too frequently to be consistent with the functions of a social life : Whereas by means of the peritoneum, the urine is now collected in sufficient quantity, the viscera not gravitating this way.

You may take it for a general rule, that those creatures that feed upon animal-food have their bladder more muscular and considerably stronger, and less capacious, than those that live on vegetables, such as horses, cows, swine, &c. whose bladder of urine is perfectly membranous, and very large. This is wisely adapted to the nature of their food : For in these first, as all their juices are more acrid, so in a particular manner their urine becomes exalted ; which, as its remora might be of very ill consequence, must necessarily be quickly expelled. This is chiefly effected by its stimulating this viscus more strongly to contract, and so to discharge its contents, though the irritation does not altogether depend upon the stretching, but likewise arises from the quality of the liquor. That a stimulus is one of the principal causes of the excretion of urine, we learn from the common saline diuretic medicines that are given, which are dissolved into the serum of the blood, and carried down by the kidneys to the bladder : The same appears likewise from the application

tion of cantharides ; or without any of these, when the parts are made more sensible, as in an excoriation of the bladder, there is a frequent desire to make water. Accordingly we find these animals evacuate their urine much more frequently than man, or any other creature that lives on vegetable food. And if these creatures, whose fluids have already a tendency to putrefaction, are exposed to heat or hunger, the liquids must for a considerable time undergo the actions of the containing vessels, and frequently perform the course of the circulation, without any new supplies of food ; by which the fluids becoming more and more acrid, the creature is apt to fall into feverish and putrid diseases : And in fact, we find that fatal and melancholy distemper the *rabies canina, vulpina, &c.* frequent in these animals ; whereas those that feed on vegetable food seldom or never contract these diseases but by infection.

Their *spermatic vessels* are within the peritoneum, which is spread over them, and from which they have a membrane like a mesentery, so hang loose and pendulous in the abdomen : whereas, in us, they are contained in the cellular part of the peritoneum, which is tensely stretched over them. At their passage out of the lower belly, there appears a plain perforation, or holes ; hence the adult quadruped, in this respect, resembles the human foetus. And from observing this in quadrupeds, has arisen the false notion of *hernia* or *rupture* among authors. This opening, which leads down to the testicle, is of no disadvantage to them, but evidently would have been to us ; for from the weight of our viscera, and our continually gravitating upon these holes, we must have perpetually laboured under enteroceles. This they are in no hazard of, since in them this passage is at the highest part of their belly, and, in their horizontal posture, the viscera cannot bear upon it : And, to prevent even the smallest hazard, there is a loose pendulous semilunar flap of fat ; which serves two uses, as it both hinders the intestines

from getting into the passage, and also the course of the fluids from being stopped in the vessels, which is secured in us by the cellular substance and tense peritoneum: And it may be worth while to observe, that this process remains almost unaltered, even after the animal has been almost exhausted of fat..

There is next a passage quite down into the cavity, where the testicles lie. Had the same structure obtained in man, by the constant drilling down of the liquor which is secreted for the lubricating of the guts, we should always have laboured under an hydrocele; but their posture secures them from any hazard of this kind: indeed your very fat lap-dogs, who consequently have an overgrown omentum, are sometimes troubled with an epiplocele.

The *scrotum* is shorter and not so pendulous as the human in all the dog kind that want the *vesiculae seminales*, that the seed at each copulation might the sooner be brought from the testes, thus in some measure supplying the place of the *vesiculae seminales*; for the course of the seed through the *vasa deferentia* is thus shortened, by placing the secreting vessels nearer the excretory organs \*. The want of *vesiculae seminales* at the same time explains the reason why this creature is so tedious in copulation. But why these bodies are absent in the dog kind more than in other animals, is a circumstance we know nothing of.

The structure of the *testicles* is much the same with the human; as are likewise the *corpus pyramidale*, *varicosum*, or *pampiniforme*, and the *epididymis* or excretory vessel of the testicle. The *vasa deferentia* enter the abdomen where the blood-vessels come out; and, passing along the upper part of the bladder, are inserted a little below the bulbous part of the urethra.

The *præputium* has two muscles fixed to it: one  
that

\* Perhaps its passage is likewise quickened by the muscular power of the *vasa deferentia*, which is stronger in this creature than in man.

that arises from the *sphincter ani*, and is inserted all along the *penis*; and this is called *retractor præputii*: But the other, whose office is directly contrary to this, is cutaneous; and seems to take its origin from the muscles of the abdomen, or rather to be a production of their *tunica carnosa*. The *corpora cavernosa* rise much in the same way as the human: but these soon terminate; and the rest is supplied by a triangular bone, in the inferior part of which there is a groove excavated for lodging the urethra. There are upon the penis two protuberant bulbous fleshy substances, resembling the *glans penis* in man, at the back of which are two veins, which by the *erectores penis* and other parts are compressed in the time of coition; and the circulation being stopped, the blood distends the large cavernous bodies. After the penis is thus swelled, the vagina, by its contraction and swelling of its *corpus cavernosum*, which is considerably greater than in other animals, gripes it closely; and so the male is kept in action some time contrary to his will, till time be given for bringing a quantity of seed sufficient to impregnate the female: and thus, by that *orgasmus veneris* of the female organs, the want of the *vesiculae seminales* are in some measure supplied.. But as it would be a very uneasy posture for the dog to support himself solely upon his hinder feet, and for the bitch to support the weight of the dog for so long a time; therefore, as soon as the bulbous bodies are sufficiently filled, he gets off and turns averse to her. Had, then, the penis been pliable as in other animals, the urethra must of necessity have been compressed by this twisting, and consequently the course of the seed intercepted; but this is wisely provided against by the urethra's being formed in the hollow of the bone. After the emission of the seed, the parts turn flaccid, the circulation is restored, and the bulbous parts can be easily extracted.

The *prostata* seems here divided into two, which are proportionably

proportionably larger than the human, and afford a greater quantity of that liquid.

The *uterus* of multiparous animals is little else but a continuation of their *vagina*, only separated from it by a small ring or valve. From the *uterus* two long canals mount upon the loins, in which the foetuses are lodged: these are divided into different sacs, which are strongly constricted betwixt each foetus; yet these coarctations give way in the time of birth. From these go out the *tubæ Fallopianæ*, so that the ovaria come to lodge pretty near the kidneys.

We ought next to examine the structure of the thorax and its contents. But first it may not be amiss to remark of the *diaphragm* in its natural situation, that it is in general more loose and free than the human; which is owing to its connection with the neighbouring parts in a different manner from ours. The human *diaphragm* is connected to the pericardium; which again, by the intervention of the mediastinum, is tied to the sternum, spine, &c. but here there is some distance between the diaphragm and pericardium. We observe further, that its middle part is much more moveable, and the tendinous parts not so large. And indeed it was necessary their *diaphragm* should be somewhat loose, they making more use of it in difficult respiration than man. This we may observe by the strong heaving of the flanks of an horse or dog when out of breath; which corresponds to the rising of the ribs in us.

The disposition and situation of the *mammæ* vary as they bear one or more young. Those of the uniparous kind have them placed between the posterior extremities, which in them is the highest part of their bodies, whereby their young get at them without the inconvenience of kneeling: Nevertheless, when the creatures are of no great size, and their breast large, as in sheep, the young ones are obliged to take this posture. In multiparous animals, they must have a great number of nipples,

that their several young ones may have room at the same time, and these disposed over both thorax and abdomen ; and the creatures generally lie down when the young are to be suckled, that they may give them the most favourable situation. From this it does not appear to be from any particular fitness of the vessels at certain places for giving a proper nourishment to the child, that the breasts are so placed in women as we find them, but really from that situation being the most convenient both for mother and infant.

The *sternum* is very narrow, and consists of a great number of small bones, moveable every way ; which always happens in creatures that have a great mobility in their spine. The ribs are straighter, and by no means so convex as the human ; whereby in respiration the motion forward will very little enlarge their thorax, which is compensated by the greater mobility of their diaphragm : so our thorax is principally enlarged according to its breadth and depth, and theirs according to its length. The want of clavicles, and the consequent falling in of the anterior extremities upon the chest, may contribute somewhat to the straitness of the ribs.

The *mediastinum* in this creature is pretty broad. The pericardium is not here contiguous to the diaphragm, but there is an inch of distance betwixt them, in which place the small lobe of the lungs lodges ; and by this means the liver, &c. of this animal, though continually pressing upon the diaphragm, yet cannot disturb the heart's motion.

The heart is situated with its point almost directly downwards, according to the creature's posture, and is but very little inclined to the left side. Its point is much sharper, and its shape more conoidal, than the human. Here the names of *right* and *left* ventricles are proper enough, though not so in the human ; which ought rather to be called *anterior* and *posterior*, or *superior* and *inferior*. The animal has the *vena cava* of a considerable

considerable length within the thorax, having near the whole length of the heart to run over ere it gets at the *sinus Lowerianus dexter*. In men, as soon as it pierces the diaphragm, so soon it enters the pericardium, which is firmly attached to it, and immediately gets into the *sinus Lowerianus*; which sinus, in the human subject, by the oblique situation of the heart is almost contiguous to the diaphragm: and by this we discover, that several authors have taken their delineations of the human heart from brutes; which is easily detected by the shape and situation of the heart, and long *vena cava*, within the thorax. This was one of the faults of the curious wax-work that were shown at London and Paris, which were plainly taken from a cow.

This situation of the heart of the creature agrees best with the shape of its thorax, which is lower than the abdomen.

The egress of the large blood-vessels from the heart is somewhat different from the human: For here the right subclavian comes off first; and as a large trunk runs some way upwards before it gives off the left carotid, and splits into the carotid and subclavian of the right side, then the left subclavian is sent off. So that neither here, properly speaking, is there an *aorta ascendens* more than in the human; but this name has probably been imposed upon it from observing this in a cow, where indeed there is an ascending and descending aorta.

From this speciality of the distribution of the vessels of the right side, which happens, though not in so great a degree, in the human subject, we may perhaps in some measure account for the general greater strength, readiness, or facility of motion, which is observable in the right arm. I believe, upon measuring the sides of the vessels, the surface of the united trunk of the right subclavian and carotid is less than that of the left subclavian and carotid, as they are separated. If so, the resistance to the blood must be less in that common

trunk than in the left subclavian and carotid: But if the resistance be smaller, the absolute force with which the blood is sent from the heart being equal, there must necessarily be a greater quantity of blood sent through them in a given time; and as the strength of the muscles is, *cæteris paribus*, as the quantity of blood sent into them in a given time, those of the right arm will be stronger than those of the left. Now children, being conscious of this superior strength, use the right upon all occasions; and thus from use comes that great difference which is so observable. That this is a sufficient cause, seems evident from fact; for what a difference is there betwixt the right and the left arm of one who has played much at tennis? View but the arms of a blacksmith and legs of a footman, and you will soon be convinced of this effect arising from using them. But if by any accident the right arm is kept from action for some time, the other from being used gets the better; and those people are left-handed: For it is not to be imagined, that the small odds in the original formation of the vessels should be sufficient to resist the effect of use and habit, (instances of the contrary occur every day); it is enough for our present argument, that where no means are used to oppose it, the odds are sufficient to determine the choice in favour of the right. Now because it is natural to begin with the leg corresponding to the hand we have most power of, this is what gives also a superiority to the right leg.

This difference is not peculiar to man, but is still more observable in those creatures in whom the same mechanism does obtain in a greater degree. Do but observe a dog at a trot, how he bears forward with his right side; or look at him when a-scraping up any thing, and you will presently see that he uses his right much oftener than he does his left foot. Something analogous to this may be observed in horses\*.

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\* It has been the opinion of some anatomists, that left-handed people,

The *thymus* of this creature is proportionably much larger than ours: whereas the glandula thyroidea is much less, and is divided into two distinct parts, or there are two separate glands; which is not the case in man. The reason of this difference is unknown, as is likewise the use of the gland itself. It is generally remarked, that these two glands do thus always supply the place of each other; that is, in such animals as have a large thymus, the glandula thyroidea is smaller, and *vice versa*. Hence we are naturally led to ascribe the same use to both, viz. the separation of a thin lymph for diluting the chyle in the thoracic duct before it be poured into the blood; then if we consider the different formation of the thorax in both, we shall readily account for the variety in the bulk of these two glands. Respiration being chiefly performed in man by the widening of the chest; the lungs at every inspiration must press upon the thymus, and consequently diminish it: but the diaphragm yielding more in the dog's inspiration, this gland is not so much pressed by the lungs, and so will be larger; and hence the glandula thyroidea will be proportionably less. Again, from the posture of this creature, we shall see that it was much more convenient for a dog to have the most part of the diluting lymph supplied by the thymus, since the neck being frequently in a descending posture, the lymph of the thyroid gland would have a very disadvantageous course to get to the thoracic duct: whereas in the human body, the thymus is really below the lacteal canal, where it makes its curvature before it opens into the subclavian; and consequently there is a necessity of a considerable share of the diluting liquor being fur-

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people, as well as those distinguished by the name of *ambidexter* (who use both hands promiscuously), have the two carotid and subclavian arteries coming off in four distinct trunks from the arch of the aorta: but no appearance of this kind has ever been observed in such bodies as have been examined for this purpose; though indeed these have been but few, and more experience might throw greater light on the subject.

nished by the thyroid gland, which is situated much higher; so that its lymph has the advantage of a perpendicular descent.

We may here observe, that the *thoracic duct* in a dog has no curvature before it enters the subclavian vein, the horizontal position of this animal allowing a favourable enough course to the chyle, so as not to need that turn to force its passage into the blood. It may likewise be observed, that such animals as walk horizontally, have the valves of the thoracic duct fewer in number than others. The horse has only a single pair; while, on the contrary, the ape resembles man in having several valves. Thus the lymph is not only forwarded in its passage, but the weight of the column is diminished.

The lungs of this creature are divided into more numerous lobes, and deeper, than they are in man, for the same reason as the liver. The left side of the thorax in this animal bears a greater proportion to the right than in man; the one being nearly as three to two, the other as four to three.

In quadrupeds, as well as in man, the lungs are closely applied to the containing parts; although this has been denied by some.

We look on it as a general rule, that all quadrupeds, as having occasion to gather their food from the ground, are provided with longer necks than man: but as a long neck not only gives the advantage of too long a lever to the weight of the head, but also, when the animal is gathering his food, makes the brain in danger of being oppressed with too great a quantity of blood, by the liquor in these arteries having the advantage of a descent, while that in the veins must remount a considerable way contrary to its own gravity; it was therefore necessary that a part of the length of the neck should be supplied by the length of the jaws. Thus we see horses, cows, &c. who have no occasion for opening their mouths very wide, yet have long jaws. Bulldogs

dogs indeed, and such animals as have occasion for very strong jaws, must of necessity have them short ; because the longer they are, the resistance to be overcome acts with a longer lever. Another exception to this general rule, is such animals as are furnished with something analagous to hands to convey their food to their mouths, as cats, apes, &c. The teeth of this creature plainly show it to be of the carnivorous kind ; for there are none of them made for grinding their food, but only for tearing and dividing it. It has six remarkable sharp teeth before, and two very long tusks behind ; both of which the ruminating animals want. These are evidently calculated for laying very firm hold of substances, and tearing them to pieces ; and the vast strength of the muscles inserted into the lower jaw, assists greatly in this action ; while the molares have sharp cutting edges, calculated for cutting flesh, and breaking the hardest bones.

Even its posterior teeth are not formed with rough broad surfaces as ours are ; but are made considerably sharper, and press over one another when the mouth is shut, that so they may take the firmer hold of whatever comes betwixt them.

The tongue, in consequence of the length of the jaws, is much longer than ours ; and as this creature feeds with his head in a depending posture, the bolus would always be in danger of falling out of the mouth, were it not for several prominences or papillæ placed mostly at the root of the tongue, and crooked backwards in such a manner, as to allow any thing to pass easily down to the jaws, but to hinder its return. By the papillæ also the surface of the tongue is increased, and a stronger impression is made on the sensation of taste. In some animals who feed on living creatures, these tenter-hooks are still more conspicuous ; as in several large fishes, where they are almost as large as their teeth in the forepart of their mouth, and near as firm and strong.

When we open the mouth, we see the amygdalæ very prominent in the posterior part of it; so that it would appear at first view, that these were inconveniently placed, as being continually exposed to injuries from the hard substances this creature swallows: but upon a more narrow scrutiny, we find this provided for by two membranous capsulæ, into which the amygdalæ, when pressed, can escape, and remove themselves from such injuries.

The *velum pendulum palati* is in this creature considerably longer than in man, to prevent the food from getting into his nose; which would happen more frequently in this animal than in man, because of its situation while feeding.

In this subject, as well as in other quadrupeds, there is no *uvula*; but then the *epiglottis*, when pressed down, covers the whole rima entirely, and naturally continues so: there is therefore a ligament, or rather muscle, that comes from the os hyoides and root of the tongue, that is inserted into that part of the epiglottis where it is articulated with the cricoid cartilage, which serves to raise it from the rima, though not so strongly but that it may with a small force be clapped down again.

It may be asked, however, Why the *uvula* is wanting here, and not in man? This seems to be, that quadrupeds, who swallow their food in an horizontal situation, have no occasion for an *uvula*, though it is necessary in man on account of his erect situation.

In the upper part of the pharynx, behind the cricoid cartilage, there is a pretty large gland to be found, which serves not only for the separation of a mucous liquor to lubricate the bolus as it passes this way, but also supplies the place of a valve, to hinder the food from regurgitating into the mouth, which it would be apt to do by reason of the descending situation of the creature's head. In man, the muscle of the epiglottis is wanting, its place being supplied by the elasticity of the cartilage.

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The *œsophagus* is formed pretty much in the same way as the human. Authors indeed generally allege, that quadrupeds have their gullet composed of a double row of spiral fibres decussating one another; but this is peculiar to ruminating animals, who have occasion for such a decussation of fibres. The action of these you may easily observe in a cow chewing her cud.

The *nose* is generally longer than in man, and its external passage much narrower. The internal structure is also better adapted for an acute smelling, having a larger convoluted surface on which the *membrana scheideriana* is spread; and this is to be observed in most quadrupeds, who have the *osca spongiosa* commonly large, and these too divided into a great number of excessively fine thin lamellæ. The sensibility seems to be increased in proportion to the surface; and this will also be found to take place in all the other senses. The elephant, which has a head pretty large in proportion to its body, has the greatest part of it taken up with the cavity of the nose and frontal sinuses; which last extend almost over their whole head, and leave but a small cavity for their brains. A very nice sense of smelling was not so absolutely necessary for man, who has judgment and experience to direct him in the choice of his food; whereas brutes, who have only their senses, must of necessity have these acute, some having one sense in greater perfection than others, according to their different way of life. We not only conclude *a priori* from the large expanded *membrana scheideriana*, that their sense of smelling is very acute, but we find it so by cows and horses distinguishing so readily betwixt noxious and wholesome herbs, which they do principally by this sense.

The external *ear* in different quadrupeds is differently framed, but always calculated to the creature's manner of life. In shape it commonly resembles the oblique section of a cone from near the apex to the basis. Hares, and such other animals as are daily exposed

posed to insults from beasts of prey, have large ears directed backwards, their eyes warning them of any danger before; rapacious animals, on the other hand, have their ears placed directly forwards, as we see in the lion, cat, &c. The slow hounds, and other animals that are designed to hear most distinctly the sounds coming from below, have their ears hanging downwards; or their ears are flexible, because they move their head for the most part with greater difficulty than man. Man again, who must equally hear sounds coming from all quarters, but especially such as are sent from about his own height, has his external ear placed in a vertical manner, somewhat turned forward. In short, wherever we see a speciality in the make of this organ in any creature, we shall, with very little reflection, discover this form to be more convenient for that creature than another. The animal also has the power of directing the cone of the ear to the sonorous body without moving the head. There are some differences to be observed in the structure of the internal ear in different animals; but we know so very little of the use of the particular parts of that organ in the human subject, that it is altogether impossible to assign reasons for these variations in other creatures.

All quadrupeds have at the internal canthus of the eye a strong firm membrane with a cartilaginous edge, which may be made to cover some part of their eye; and this is greater or less in different animals as their eyes are more or less exposed to dangers in searching after their food. This *membrana nictitans*, as it is called, is not very large in this animal. Cows and horses have it so large as to cover one half of the eye like a curtain, and at the same time is transparent enough to allow abundance of the rays of light to pass through it. Fishes have a cuticle always over their eyes, as they are ever in danger in that inconstant element. In this then we may also observe a sort of gradation.

All quadrupeds have a seventh muscle belonging to the

the eye, called *suspensorius*. It surrounds almost the whole optic nerve, and is fixed into the sclerotic coat as the others are. Its use is to sustain the weight of the globe of the eye, and prevent the optic nerve from being too much stretched, without obliging the four straight muscles to be in a continual contraction, which would be inconvenient: at the same time this muscle may be brought to assist any of the other four, by causing one particular portion of it to act at a time.

The next thing to be remarked is the figure of the *pupil*, which is different in different animals, but always exactly accommodated to the creature's way of life, as well as to the different species of objects that are viewed. Man has it circular, for obvious reasons: an ox has it oval, with the longest diameter placed transversely, to take in a larger view of his food: cats, again, have theirs likewise oval, but the longest diameter placed perpendicularly; they can either exclude a bright light altogether, or admit only as much as is necessary. The pupil of different animals varies in wideness, according as the internal organs of vision are more or less acute: Thus cats and owls, who seek their prey in the night, or in dark places, (and consequently must have their eyes so formed as that a few rays of light may make a lively impression on the retina), have their pupils in the day-time contracted into a very narrow space, as a great number of rays would oppress their nice organs; while in the night, or where the light is faint, they open the pupil, and very fully admit the rays. In the same way, when the retina is inflamed, a great number of rays of light would occasion a painful sensation; therefore the pupil is contracted: on the contrary, in dying people, or in a beginning amaurosis, it is generally dilated, as the eyes on such occasions are very difficultly affected, and as it were insensible.

The posterior part of the choroid coat, which is called *tapetum*, is of different colours in different creatures. For oxen, feeding mostly on grass, have this membrane

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of a green colour, that it may reflect upon the retina all the rays of light which come from objects of that colour, while other rays are absorbed : Thus the animal sees its food better than it does other objects. Cats and owls have their tapetum of a whitish colour ; and for the same reasons have the pupil very dilatable, and their organs of vision acute : And we shall find, that all animals see more or less distinctly in the dark, according as their tapetum approaches nearer to a white or black colour. Thus dogs, who have it of a greyish colour, distinguish objects better in the night than man, whose tapetum is dark brown, and who, I believe, sees worst in the dark of any creature ; it being originally designed that he should rest from all kinds of employment in the night-time. The difference then of the colour of the tapetum, as indeed the fabric of any other part in different creatures, always depends on some particular advantage accruing to the animal in its peculiar manner of life from this singularity.

We shall now proceed to the BRAIN, which we remark in the first place is proportionally much smaller in all quadrupeds than the human ; but, as in man, it is divided into cerebrum and cerebellum, and these two parts bear nearly the same proportion to one another as in us. There was no such occasion for so great a quantity of brain in those animals as in man ; seeing in them all its energy is employed in their progression, while man has a great waste of spirits in the exercise of his reason and intellectual faculties. And besides all this, a great bulky brain would be inconvenient to these creatures, in so far as it would add considerably to the weight of the head ; which having the advantage of a long lever to act with, would require a much greater force to support it than now it does ; for the heads of the greatest part of quadrupeds are not near so heavy as they would at first seem to be, from the *sinus frontales* being produced a great way upwards to enlarge the organs of smelling. :

The pits in the anterior part of their skulls are much more conspicuous than in the human cranium; which may be occasioned by the depending posture of these creatures heads while they gather their food: the brain at this time gravitating much on the bones while they are as yet soft, will gradually make impressions upon them at these places where it rises into eminences. This is prevented in man mostly by his erect posture.

The *falx* is not near so large in quadrupeds as in man, as they have little occasion to lie on either side, and the two hemispheres of the brain are in a great measure hindered from jostling against one another in violent motions, by the brain's insinuating itself into the above-mentioned pits.

The second process of the *dura mater*, or *tentorium cerebello super-expansum*, is considerably thicker and stronger in most quadrupeds than in man; especially in such of them as are very swift of foot, as hares and rabbits, and that most when they are old. This membrane is generally ossified, or we find the place of it supplied by a bone, that it may the more effectually keep off the superincumbent brain from the cerebellum in their rapid motions, which otherwise would be of bad consequence.

The olfactory nerves are very large, and justly deserve the name of *processus mamillares*. They are hollow, and consist of a medullary and cineritious substance, and at first sight appear to be the anterior ventricles of the brain produced; but in man they are small, and without any discernible cavity. The reason of this is pretty evident, if we consider how this animal's head is situated; for the lymph continually gravitating upon the inferior part of the ventricles, may thus elongate and produce them; but from this very inferior part the olfactory nerves rise, and are sent immediately through the *os ethmoides* into the nose. Hence the ancients, thinking they were continued hollow

low into the nose, believed they were the emunctories of the brain: In the brain of sheep, which by its firm texture is the best subject of any for searching into the structure of this part, we evidently see, that the name of the *sigmoid cavity* was very properly applied by the ancients to the lateral ventricles of the brain; which are really of a greater extent than they are ordinarily painted by the anatomists, reaching farther backwards, and forwards again under the substance of the brain. The cortical and medullary parts, as well as the *corpus callosum*, are similar to those parts in man.

The *nates* and *testes* deserve this name much better here than in the human body, with respect to each other. They are larger in the quadruped; and hence we perceive that there is no great reason for ascribing the different operations to any particular size or shape of these parts. They are here also of different colours; the *nates* being of the colour of the cortical, and the *testes* of the medullary substance of the brain; whereas in man they are both of one colour. The reason of these differences, and others of the like nature to be met with, I shall not pretend to determine; for we have hitherto such an imperfect knowledge of the brain itself, that we are entirely ignorant of the various uses of its different parts. We may in general conclude, that the varying in one animal from what it is in another, is fitted to the creature's particular way of living.

The *rete mirabile Galeni*, situated on each side of the *sella turcica*, about which there has been so much dispute, is very remarkable in most quadrupeds. This plexus of vessels is nothing else than a continuation of the internal carotid arteries, which, entering the skull, divide into a vast number of minute branches running along the side of the *sella turcica*, and, uniting afterwards, are spent on the brain in the common way. Galen seems with justice to suppose, that this plexus

of vessels serves for checking the impetuosity of the blood destined for the brain.

The structure of the brain differing but very little in all quadrupeds, it will be needless to examine it in any other.

### The MUSCLES of a DOG.

IN the following description, it is not intended to give a complete account of the muscles of the dog, but only of the particulars wherein they differ from those of the human species; at the same time that care has been taken to make their names agree as near as possible with those of modern authors.

It is also to be understood, that those muscles concerning which nothing is here said, in general agree with those of the human species.

**PANNICULUS CARNOSUS.**—Immediately below the skin lies a thin fleshy expansion, covering the greatest part of the body, and surrounding the other muscles; It runs over the head, neck, and greatest part of the thorax and abdomen, and covers the whole of the back ilium, sacrum, and upper part of the thighs. From the thorax a slip runs over the axilla, where it is collected into a thick fold that terminates in the latissimus dorsi. In man there is nothing similar to this, excepting the platysma myoides, or the occipito-frontalis. The use of this thin muscle is to wrinkle the skin, in order to shake off dust, insects, &c. By this also the animal has a power, in some measure, of making the hair stand on end, particularly on the neck.

### MUSCLES of the TEGUMENTS of the CRANIUM.

**Occipito-frontalis.** In man this is a distinct muscle covering all the upper part of the head, beginning at the occiput, and ending at the under part of the brow.

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In a dog this is only part of the panniculus carnosus ; and therefore is common to the head and rest of the body.

*Corrugator supercilii* wanting.

#### MUSCLES OF THE EAR.

The muscles of the ear of this animal differ considerably from those in the human ear, where little motion seems to have been intended. In a dog, the motions of the ear are free and extensive ; and hence a greater number of muscles were required : But several of these are so small, that perhaps it may be sufficient to describe two of the principal of them.

*Retrahens*, a large and distinct muscle arising from the spinous processes of the two or three first cervical vertebræ, and running over to be fixed to the concha at its lateral and upper part. Its name denotes its use.

*Erigens*, arises from a ridge on the occipital bone, and runs over by three distinct fleshy slips to be fixed to the outer part of the ear, and serving to erect or prick it up.

There are likewise a number of very distinct muscles belonging to the internal ear.

*Laxator tympani* is a short muscle, of an oval form and glandular appearance, lying in a particular cavity of the os petrosum, near the foramen ovale ; from the bottom of which it springs, and is inserted by a very slender tendon into the malleus. The use is, as in man, to relax the membrana tympani, by rendering it less concave.

*Musculus meatus auditorius*. In a dog there are several small muscles which come from one of the protuberating cartilages of the concha, and end in another of them ; which, by putting them nearer together or farther asunder, may dilate or contract the meatus externus, the better to fit it for different sounds.

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## MUSCLES of the EYE.

The muscles which belong to the eye of a dog are similar to those in man; but, from the difference of situation of the head, the dog has an addition of two others not found in the human species.

All quadrupeds have a seventh muscle belonging to the eye, called *suspensorius*. It surrounds almost the whole optic nerve, and is fixed into the sclerotic coat as others are. Its use is to sustain the weight of the globe of the eye, and to prevent the optic nerve from being too much stretched, without obliging the four straight muscles to be in a continual contraction, which would be inconvenient; at the same time this muscle may be brought to assist any of the four, by causing one particular portion of it to act at a time.

*Musculus trochlearis proprius* is by much the smallest muscle of the eye. It arises fleshy near the origin of the *obliquus major*; and soon sends off a slender tendon, which is inserted into the *trochlea*; to the motions of which it is subservient.

## MUSCLES of the FACE.

**Nose.** The nose of a dog has no proper muscle as in the human body; but is moved by muscles which are common to it and to the rest of the face.

**MOUTH.** The lips of a man are moved by nine pair of muscles and a sphincter; but a dog has only six pair and the sphincter.

*Levator anguli oris* wanting.

*Levator labii superioris* arises and is inserted in the dog in a manner somewhat similar to what it is in man. Its use is to pull up the lip, which the animal does principally in snarling.

*Depressor labii superioris* as in man.

*Depressor anguli oris* wanting.

VOL. III.

B b

Dec.

*Depressor labii inferioris* arises from the middle of the lower jaw, and runs up to be fixed to the under lip.

*Levator labii inferioris* as in man.

*Zygomaticus major* has many of its fibres spread out upon the buccinator muscle, by which the corner of the mouth is forcibly drawn upwards.

*Buccinator* as in man.

*Zygomaticus minor* wanting.

### MUSCLES of the LOWER JAW.

*Temporalis* arises and is inserted almost in the same manner as in man; but is much thicker and stronger in proportion to the size of the animal; as indeed might be naturally expected, when we consider the very hard and strong substances which dogs are capable of breaking and tearing asunder with their teeth.

*Masseter* arises and is inserted also somewhat in the same manner as in man; and, like the temporal muscle, is thick and strong, that the jaws may be brought more forcibly together.

*Pterygoideus internus et externus* arise close together from the sphenoid bone, and are inserted as in man.

### MUSCLES about the NECK, THROAT, &c.

*Platysma myoides*. A dog has no proper platysma myoides; but the panniculus carnosus runs over the neck, and serves the same purpose.

*Sterno-C-mastoidæus*. As the dog has no clavicle, this muscle arises by one head from the top of the sternum, and runs half way up the neck, contiguous to its fellow on the other side; here it separates from it, and runs up to be inserted as in man.

*Digastricus*, in man, has two fleshy bellies, with a tendon in the middle; but in the dog it arises by a very thick and strong fleshy belly, from between the mastoid

mastoid process of the temporal and condyloid process of the occipital bones, and runs forward to be fixed by a broad insertion into the middle of the lower jaw. Its use is to counteract the temporal and masseter muscles by bringing down the jaw.

*Sterno-hyoïdæus*, in man; arises from the sternum, first rib, and clavicle. In the dog, it arises, in common, with the sterno-thyroidæus muscle, from the cartilaginous extremity of the first rib. After running along the neck a short way, it leaves the sterno-thyroid muscle, and runs, as in man; to the base of the os hyoides.

*Omo-hyoïdæus* wanting.

*Sterno thyroidæus* arises in common with the sterno-hyoïdæus.

*Chondro-cerato-hyoïdæus* arises from the superior corner of the thyroid cartilage, and is inserted into the cartilaginous appendix of the os hyoides. Its use is to draw these bodies closer together. In man this muscle is wanting.

*Stylo-glossus*, in man, arises from the styloid process. In the dog it arises from the extremity of the long process of the os hyoides; and therefore ought to be called *hyo-glossus*.

*Inio cerato-hyoïdæus*, a very short fleshy muscle, arising from the head by the side of the digastric muscle of the lower jaw; and is inserted near the extremity of the long process of the os hyoides, which it pulls backwards.

*Stylo hyoïdæus alter*, wanting.

*Stylo pharyngæus* arises from the extremity of the long process of the os hyoides.

*Circumflexus*, or *tensor palati*, arises from the beginning of the Eustachian tube; adheres firmly to the soft part, where it becomes fleshy; and afterwards sends off a tendon which runs over the inner plate of the pterygoid process of the sphenoid bone. It is inserted into the palatum molle, and likewise joins its

fellow on the other side. The use of this muscle is to pull the soft part of the palate from the posterior part of the nostrils, to compress the glands of the palate which lie near it. It may likewise assist in dilating the soft part of the Eustachian tube.

*Constrictor isthmi faucium* may not only serve the common purposes as in man, but likewise act upon a glandular body which is placed in the throat, near the amygdalæ.

*Azygos uvulae.* Although the uvula is wanting in this animal, a bundle of muscular fibres runs through the middle of the palatum molle, somewhat in the same manner as in man.

*Hyo-epiglottidæus.* In man, the epiglottis is raised by the elasticity of its cartilage; but in the dog there is a very distinct muscle, which arises from the body and cartilaginous process of the os hyoides, and runs down to be inserted into the middle of the upper part of the epiglottis, near its top. Its use is to raise the epiglottis after swallowing.

### MUSCLES of the ABDOMEN.

*Obliquus externus descendens* arises fleshy, by nine or ten heads, from an equal number of posterior ribs; membranous, from the spinous processes of the four anterior lumbar vertebræ, and from the spine of the os ilium. From these different origins it runs over and downwards to the edge of the rectus muscle. Here it assists in forming the linea semilunaris, and is then continued over the rectus by a thin tendinous expansion to be inserted into the linea alba. A thin tendinous expansion may be traced down with the chord.

*Obliquus ascendens internus*, at a little distance from the outside of the rectus muscle, becomes tendinous, and is continued so over the fore-part of that muscle, to be fixed to the linea alba.

*Rectus abdominis* arises fleshy from the pubes, and runs up to be fixed to the under end of the sternum; and

## COMPARATIVE ANATOMY.

381

and about the 5th or 6th rib it sends off a tendinous expansion, which covers the cartilages of the ribs, and is continued to the top of the sternum. It has the same use as in man; but its under end being fleshy, serves in some measure to make up for the *Pyramidalis*, which is wanting.

### MUSCLES of the MALE PARTS of GENERATION.

The muscles in general are thicker and stronger than in man. The *transversalis perinei* is wanting, but there is an addition of three or four muscles which are not found in the human species.

*Transversalis penis*, a small but distinct muscle, which arises behind the erector penis from a small protuberance at the under and posterior part of the os pubis. It is inserted with its fellow into a tendon between the os pubis and penis. This muscle may assist in keeping the penis distended in time of copulation.

*Præputium adducens* arises from the panniculus carnosus near the *cartilago ensiformis*; and runs along the side of the linea alba, to be fixed to the lateral part of the prepuce. Its use is to bring the prepuce forward over the glans, after an erection of the penis.

*Præputium abducens* is a single muscle which arises by a small fleshy belly from the *sphincter ani* and *accelerator urinæ*; at the fore-part of which it runs along the under side of the urethra, to be inserted into the prepuce. Its use is to counteract the former muscle.

*Musculus urethrae* surrounds that part of the urethra which lies between the prostate gland and union of the crura penis. Its use is to compress that part of the mucous glands and urethra which it covers in time of coition.

Muscles of the *Female Organs of Generation* agree in general with those of the human species.

## MUSCLES of the ANUS.

*Sphincter ani* surrounds the anus, as in man; but is much narrower, less force being required here from the horizontal situation of this animal.

*Levator ani* arises as in man; but divides into three or four portions, one of which runs into the tail, and assists in compressing it.

## MUSCLES about the PELVIS, LOINS, &amp;c.

*Musculus parvus in articulatione femoris situs* arises near the upper edge of the acetabulum, and runs over the capsular ligament of the joint, to be fixed to the os femoris between the vastus internus and cruræus. Its use is to assist the obturator externus in the rotation of the thigh.

*Musculi caudæ.* The tail of this animal, which is made up of many joints, has several muscles fixed into it. They begin with fleshy bellies, which soon send off long tendons; some of which run as far as the extremity of the tail, and serve to give it its different motions which are upwards, downwards, and to each side; or, by a succession of these motions, the animal can roll its tail.

*Quadratus lumborum* is a small slender muscle; the anterior and upper end of which is contiguous to the psoas parvus; the posterior end to the psoas magnus. It arises from the spine of the ilium internally; and, ascending, is inserted into the transverse processes of all the lumbar vertebræ, and likewise into the 9th or 10th rib.

*Psoas parvus*, a large distinct muscle, which is constantly present, arising from the four lowest vertebræ of the back and as many of the loins, soon forming a fleshy belly, which sends off a broad expansion that runs by the inside of the psoas magnus; part of which

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it covers and conceals. At last it is fixed, as in man, to the brim of the pevis.

### MUSCLES situated on the THORAX.

*Pectoralis major* in a dog, differs from that in man, in being divided into three distinct parts. The first arises from the upper part of the sternum; and, passing over the third, is inserted under it by a strong broad tendon into the whole length of the external and fore-part of the os humeri. The second arises from the under end of the sternum and cartilago ensiformis, and covers a considerable share of the under part of the next muscle. It is inserted partly with the next muscle, and partly runs down upon the muscles on the humerus. The third, and by much the broadest part, arises from the cartilago ensiformis and all the sternum. It is inserted into the head of the os humeri.

*Subclavius* wanting, as the dog has no clavicle.

*Pectoralis minor* wanting.

*Serratus major anticus*, arises fleshy from the five posterior transverse processes of the vertebræ of the neck, tendinous and fleshy from the seven anterior ribs; from the neck it runs obliquely downwards, from the ribs it runs obliquely upwards. It is inserted into the posterior angle of the scapula internally. It may pull the scapula upwards, downwards, and backwards.

*Sterno-costalis*, in a dog, is much larger and stronger than in man; of consequence it may act more powerfully on the thorax.

*Longus colli*, in a dog, is much more distinct in every respect than in man, its fleshy bellies being divided by tendinous lines equal in number to the vertebræ of the neck.

*Rectus capitis internus major* arises by a number of tendinous and fleshy beginnings from the transverse processes of all the vertebræ of the neck except the first; over the inside of which it is reflected in its pas-

sage to the head. It is inserted in a small cavity in the cuneiform process of the occipital bone.

#### MUSCLE situated on the POSTERIOR PART of the TRUNK.

*Trapezius* arises from the ligamentum nuchæ and vertebræ of the back. It is inserted into all the spine of the scapula except its fore-part, where it unites with the levator scapulæ major.

*Latissimus dorsi* is membranous as far as the under part of the thorax, and is afterwards covered as in man by the trapezius. When it arrives at the teres major, it parts with a thin fleshy production, which, running down upon the long head of the triceps, is inserted tendinous into the elbow. A little before this, it receives the continuation of the panniculus carnosus.

*Serratus posticus inferior* arises by a thin tendon from the posterior part of the ligamentum nuchæ, and from the spinous processes of the eight anterior vertebræ of the back. It is inserted into the anterior ribs excepting the first, by as many fleshy indentations. Its tendon joins with that of the serratus posticus inferior; and with it makes a tendinous sheath which keeps the subjacent muscles together, and strengthens them in their action.

*Longissimus dorsi* and *sacro-lumbalis* are similar to that in man, but much stronger.

*Complexus* arises from the transverse processes of the four anterior vertebræ of the back by as many small tendons, from the posterior vertebræ of the neck by as many different heads, which, uniting, form a fleshy belly that is inserted into the occipital bone near its ridge.

*Trachelo-mastoideus*, a little before it reaches the head is firmly united to the splenius muscle.

*Levator scapulæ major* arises fleshy from the transverse process of the first vertebra of the neck, and runs along

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the side of the neck to be inserted in common with the trapezius into the spine of the scapula.

*Levator scapulæ minor* arises tendinous from the occipital bone, runs down the back part of the neck, and in its passage joins the long portion of the rhomboid muscle, to be inserted by a long tendon into the base of the scapula near its angle. The two serve to raise the scapula; the anterior may raise the fore-part, and the posterior the back-part.

*Multifidus spinæ*, in general, agrees with that in man, but the upper part of it is inserted into the bodies of the cervical vertebræ.

*Rectus*. In the dog there are three recti muscles.

*Rectus major* arises from the spinous process of the second vertebra of the neck, and runs straight forward, covering the *rectus medius*.

*Rectus medius* arises from the upper part of the same process, and is inserted with the former.

*Rectus minor* the same as in man.

*Obliquus capitis superior*, like the *rectus major*, is also double. One part arises from the extremity of the transverse process of the first vertebra of the neck, the other from its upper edge; and both are inserted into the occipital bone.

*Scalenus*, as in man, may be divided into three muscles; but the *scalenus medius* is broader, and is inserted into the fifth or sixth rib.

*Musculus in summo thorace situs* arises fleshy from the first rib; and afterwards turns tendinous to be inserted into the sternum, under the tendon of the *rectus abdominis*.

*Intertransversalis colli* is much thicker and stronger than in man.

### MUSCLES OF THE SUPERIOR EXTREMITIES.

*Infraspinatus* has the middle tendon and penniform appearance much more distinct than in man.

*Teres*

*Teres minor* arises by a slender tendon, which adheres forwards to the under edge of the infraspinatus; then it forms a fleshy belly, which passes obliquely over the beginning of the biceps muscle, to be inserted into the head of the os humeri.

*Deltoides* arises tendinous from almost all the spine of the scapula. That part which comes from the acromion seems to be distinct from its other origin, but cannot be divided from it without violence. Its action is upwards and outwards; for it has no beginning from the clavicle to move it inwards.

*Coraco-brachialis* is a small muscle arising from the upper part of the superior costa scapulæ by a very slender tendon; which, passing over the head of the humerus, grows fleshy, and is inserted into the inside of that bone about an inch or more below its neck.

*Subscapularis* possesses only about three parts of the surface of the scapula, the serratus magnus possessing the rest.

Besides the muscles already described, the dog has two others peculiar to himself.

*Levator humeri proprius* arises from all the space between the tendinous end of the mastoid muscle and ridge of the occiput, from the anterior part of the ligamentum nuchæ. This large beginning becomes narrower as it runs obliquely along the neck, closely adhering to some part of the levator scapulæ major; and, passing over the articulation of the humerus, goes straight down to its insertion in the fore, and near the under part of the same bone.

*Musculus ad levatorem accessorius*, arises from the os occipitis near the insertion of the mastoid muscle, and unites with the former a little before it reaches the scapula. Just above the head of the os humeri, near the termination of the muscle, there is placed a small crooked body, of a cartilaginous nature, tied to the scapula and top of the sternum by two small ligaments; which is all that the animal can be said to have for a clavicle.

In

In cats, this muscle is inserted into the whole length of the clavicle, which it serves to raise: but in this animal the use of the accessory muscle seems calculated for the assistance of the levator, which serves to raise the os humeri, and to turn it a little outwards, whereby the fore-feet are kept from injuring each other in running or leaping.

*Biceps*, in this animal, ought to be distinguished by some other name, as *flexor cubiti anterior*. It rises here by one head from the cervix scapulæ, and runs down above the following muscle to be inserted by two tendons as in man.

*Brachialis anternus* rises broad and fleshy from the back of the humerus under its neck, and runs down by the outside of the former muscle.

The extension of the cubit or fore-arm is performed by the action of five muscles.

*Extensor primus*, and what corresponds with the long head of the triceps in man, becomes very thick and fleshy; but afterwards sends off a tendon, which is inserted into the olecranon.

*Extensor secundus*, corresponding with the short head of the triceps, arises from the superior and back part of the humerus, and, descending under the former, sends off a tendon through a fulcus in the extremity of the ulna, and is inserted below the other muscles.

*Extensor tertius*, something analogous to the brachialis externus in man, arises from the upper and back part of the humerus at a protuberance near the termination of the teres minor, to be inserted into the outside of the olecranon.

*Extensor quartus*, or *anconæus*, fills up a cavity or hollow between the heads of the radius and ulna, and has the same origin and termination as in man.

*Extensor quintus* arises by a thin tendon from the inside of that protuberance into which the supraspinatus of the scapula is inserted; and passing under the tendon of the teres major, ends at the inside of the olecranon.

*Palmaris*

*Palmaris longus* wanting.

—*brevis* wanting.

*Flexor carpi ulnaris*.—Here we find two distinct muscles. The

*Large* arises from the internal condyle of the os humeri near the edge of the sinus that receives the head of the ulna, and is inserted into the carpus. The

*Smaller* arises fleshy from the olecranon, and runs down by the side of the former to terminate with it in the carpus.

*Extensor carpi radialis longior et brevior*, similar to those in man, but more firmly united together at their origin.

*Extensor carpi ulnaris* sends a tendon to the carpus, which pulls that part out in extension, and assists the animal in running.

*Flexor sublimis perforatus*. The openings through the tendons of this muscle for the passage of the next, are much larger and wider than in man, and the tendons terminate without any subdivision.

*Flexor profundus perforans* arises from the os humeri, radius, and ulna, by three distinct heads, which unite, and afterwards send off a strong tendon, which splits into five small ones; four of which terminate as in man; the fifth is inserted into the part which corresponds with the thumb.

*Extensor digitorum communis* runs to the last bone of each toe between the two ligaments that go from the second bone of the toe to the third. The use of these ligaments is to draw the last joint backwards and upwards, and keep it suspended, that the extending tendon may not always be upon the stretch.

*Supinator radii longus* wanting.

*Pronator radii quadratus* lies upon the membrane that joins the two bones of the cubit together, to both of which it adheres; and near the under end of the ulna sends off a tendon obliquely to the extremity of the radius, into which it is inserted.

*Indicator* arises as in man, but is inserted into the last joint of what corresponds with the fore-finger.

*Abductor indicis manus* wanting.

*Flexor primi internodii* wanting.

*Extensor tertii internodii* wanting.

*Interossei.*—A dog has interossei muscles somewhat similar to those in man, and they are six in number; four of which are large, and placed, not between, but in the hollow of the metacarpal bones, and run straight down. The other two are very small, and run oblique. The large arise tendinous and fleshy from the superior part of the metacarpal bones, adhering to the same in their descent: at the os sesamoideum of the first joint, each divides into two tendons; which running obliquely along the sides of the toe, unite inseparably with the tendon of the extensor near the lower part of the first bone of each toe.

The first of the two small muscles belongs to the fore-toe or index. It arises from the upper part of the os metacarpi medii digitii; and, descending obliquely, grows tendinous about the first joint, and terminates near the middle of this bone internally.

The second arises from the os metacarpi of the third toe; and after running obliquely, ends in the inside of the first bone of the little toe. The use of these two muscles is to bring their respective toes nearer the middle one.

*Abductor indicis* wanting.

*Flexor primi internodii* wanting.

#### MUSCLES OF THE INFERIOR EXTREMITIES.

*Psoas magnus.*

*Pectinalis*, from the os pubis, and terminates by a broad and thin tendon at the inner condyle of the femur.

Besides the *triceps adductor femoris*, a dog has a *musculus parvus in articulatione femoris situs*, which arises from the side of the acetabulum, and is inserted into the

the upper inner part of the os femoris, after running over the capsular ligament of the joint.

*Glutæus medius* here, ought rather to be called *glutæus maximus*. The principal difference between the glutæi muscles and those of man is, that the middle glutæus is by much the largest.

*Tensor vaginæ femoris* is divided into two distinct muscles. The superior arises from the spine of the os ilium, and ends as in man. The inferior arises from below the former, and with it is inserted into the same tendon.

A dog has the addition of a *fifth extensor*, which arises from the spine and half the costa of the os ilium. In its descent it adheres to the sartorius by a membrane, and is inserted into the patella.

*Biceps flexor cruris* nearly as in man, excepting that its short head is much smaller.

*Gastrocnemius* has but two heads; whereas in man it has four.

*Plantaris* arises in common with the flexor digitorum communis.

*Tibialis anticus* sends off a tendon which runs upon the great toe, which it serves to extend.

*Tibialis posticus*, a very small muscle when compared with that in man.

*Extensor longus digitorum* arises by a round tendon from the fore-part of the external condyle of the os femoris; and descending through a sinus in the head of the tibia, grows fleshy after passing under the ligament similar to that of the tarsus in man. Inserted into the ends of the toes.

*Extensor brevis digitorum* may be said to be two distinct muscles. The first arises tendinous, the other fleshy from the os calcis. The first soon becomes fleshy, and afterwards sends off a tendon, which ends in the toe next the great one. The second, or outermost, gives tendons to the rest of the toes.

*Flexor brevis digitorum* arises from the lower part of the

• the os femoris, and runs under the gastrocnemius, to which it adheres. It afterwards runs over the os calcis, and splits into four tendons, which give passage to the following muscle.

*Flexor longus digitorum* splits into five tendons : one runs to the great toe ; the rest run through the tendons of the former to the other toes.

*Flexor digitorum accessorius* wanting.

*Extensor proprius pollicis.* Somewhat similar to that in man ; but, besides it, there is a tendon sent off from the lower part of the tibialis posticus, which runs along the upper part of this toe, and assists in extending it.

*Flexor brevis pollicis*, in this animal, is a thin slip sent off from the flexor profundus.

*Abductor pollicis* wanting.

*Adductor pollicis* wanting.

*Abductor minimi digiti* wanting.

*Flexor brevis minimi digiti* wanting.

*Interossei.* The hind-foot, like the fore-one, has six muscles, four of which are straight, the other two oblique ; and the whole of them serve the same purpose as the interossei in man.

### MUSCLES peculiar to MAN.

*Pyramidalis.*

*Corrugator supercilii.*

*Compressor naris.*

*Levator anguli oris.*

*Depressor anguli oris.*

*Zygomaticus minor.*

*Omo-hyoidæus.*

*Levator palati.*

*Palato-pharyngæus.*

*Subclavius.*

*Pectoralis minor.*

*Supinator longus.*

*Palmaris longus.*

**Palmaris brevis.**

**Prior indicis.**

**Abductor indicis.**

All the muscles of the thumb, excepting one flexor and one extensor.

All the muscles of the little finger, excepting the extensor.

**Coccygæus.**

### MUSCLES peculiar to the DOG.

**Transversalis penis.**

**Musculus oculi suspensorius.**

**Musculus trochleæ proprius.**

Several muscles of the ear.

**Chondro-cerato-hyoidæus.**

**Inio-cerato-hyoidæus.**

**Hyo-glottis.**

**Tympano-palatinus.**

**Musculus in summo thorace situs.**

**Levator scapulæ minor.**

**Panniculus carnosus.**

**Levator humeri proprius.**

**Musculus ad levatorem accessorius.**

**Extensor cubiti quintus.**

**A second flexor carpi ulnaris.**

**Musculus parvus in articulatione situs.**

**Musculi caudæ.**

**Extensor tibiæ quintus.**

**Præputium adducens.**

**Præputium abducens.**

**Musculus urethræ.**

The

## The ANATOMY of a COW.

THE next species of quadrupeds we proposed to consider, was the ruminant kind, of which we have an example in a cow; and accordingly shall take the foetus of the animal *in utero*, that we may first remark some things that are peculiar to it in that state, and afterwards proceed to examine its viscera as a ruminant animal. First, then, as a foetus.—However, before we begin our inquiry, it may be worth our observation, that from the ovary something essentially necessary for the production of the foetus is derived, as well as in the human species.

The form of a cow's *uterus* differs from the human, in having two pretty large cornua. This is common to it with other brutes; for a bitch has two long *cornua uteri*: But these again differ (as being multiparous and uniparous) in this, that in the bitch's cornua the foetuses are contained; whereas here there is only part of the secundines, being mostly the allantois with the included liquor. The muscular fibres of the uterus are more easily discovered; its internal surface has a great number of spongy, oblong, protuberant, glandular bodies fixed to it. These are composed of vessels of the uterus terminating here. In an impregnated uterus, we can easily press out of them a chylous mucilaginous liquor; they are composed of a great many processes or digituli, and deep caverns, answering to as many caverns and processes of the placenta. Their resemblance has occasioned the name of *papillæ* to be given them; and hence it was that Hippocrates was induced to believe that the foetus sucked *in utero*. The papillæ are found in all the different stages of life, in the various stages of pregnancy, and likewise in the unimpregnated state. It is not easy to determine whether the uterus grows thicker or thinner in the time of ges-

tation. The membranes, it is plain, (by the stretching of the parts), must be made thinner; but then it is as evident, that the vessels are at that time enlarged, upon which principally the thicknes of any part depends; so there seems to be as much gained the one way as lost the other.

The *os uteri* is entirely shut up by a glutinous mucilaginous substance, that is common to the females of all creatures when with young: by this the external air is excluded, which would soon make the liquors corrupt; it also prevents the inflammation of the membranes, and the hazard of abortion. By this means also the lips of the womb are kept from growing together, which otherwise they would certainly at this time do. There are mucous glands placed here to seern this gluten, which on the breaking of the membranes with the contained waters make a sapo that lubricates and washes the parts, and makes them easily yield. The first of the proper involucra of the foetus is the chorion.

The *chorion* is a pretty strong firm membrane, on whose external surface are dispersed a great many red fleshy bodies of the same number, size and structure with the papillæ, with which they are mutually indent-ed. They have been called *cotyledones*, from Κοτύλη, “cavity.” This is greatly disputed by some as a name very improper; but I think without reason, since the surface that is connected to the papillæ is concave, though when separated it appears rather convex. To shun all dispute, they may be called properly enough *placentulæ*, since they serve the same use as the placenta in women. The separation of these from the papillæ without any laceration, and our not being able to inject coloured liquors from the vessels of the glands of the uterus into the placentulæ, seem to prove beyond a reply, that there can be here no anastomoses betwixt the vessels; on their coats run a great number of vessels that are sent to the several placentulæ, on the exter-

external side next to the uterus ; whereas in creatures that have but one placenta, as in the human subject, cats, dogs, &c. the adhesion is somewhat firmer : The placentæ are likewise joined to the papillæ in the cornua uteri. We shall next give the history of the *allantois*.

This is a fine transparent membrane contiguous to the former. It is not a general involucrum of the foetus in the mother, for it covers only a small part of the amnios. It is mostly lodged in the cornua uteri. In mares, bitches, and cats, it surrounds the amnios, being every-where interposed betwixt it and the chorion. In sheep and goats it is the same as in this animal ; and in swine and rabbits it covers still less of the amnios. This sac is probably formed by the dilatation of the urachus, which is connected at its other end to the fundus of the bladder, through which it receives its contents ; and a great quantity of urine is commonly found in it. The membrane is doubled at the extremity of the canal, to hinder the return of the urine back into the bladder. Its vessels are so excessively fine and few, that we cannot force an injected liquor farther than the beginning of this coat. This membrane is so far analogous to the cuticula, as not to be liable to corruption, or easily irritated by acrid liquors. The existence of this membrane in women has been very warmly disputed on both sides. Those who are against its existence deny they could ever find it ; and, allowing it were so, allege, that since the urachus is impervious, as appears by our not being able to throw liquors from the bladder into it, or *vice versa*, it cannot serve the use that is agreed by all it does serve in beasts ; and therefore in the human body there is no such thing. But when I considered on the other hand, first, that there seems to be the same necessity for such a reservoir in man as in other animals : secondly, that we actually find urine contained in the bladder of the human foetus : thirdly, that urine has been evacuated

at the navel when the urethra was stopped, which urine without this conduit would have fallen into the cavity of the abdomen: fourthly, that midwives have pretended to remark two different sorts of waters come away at the time of birth: and lastly, that Dr Littré and Dr Hale have given in this membrane of an human subject, with all the other secundines curiously prepared, the one to the royal academy at Paris, the other to the royal society at London; by which societies their respective accounts are attested; not to mention Verheyen, Heister, Keill, &c. who affirm their having seen it; and Mr Albinus, that famous anatomist, professor at Leyden, shows, as I am told, to his college every year a preparation of it: On all these accounts I must own, that it seemed not improbable to me there was such a membrane in the human body. But in four bodies I purposely dissected, wherein I was assisted by a very accurate anatomist, Dr Sinclair, I could not observe any such thing. However, my want of skill will more probably be doubted, than the truth of relations, supported by such authentic vouchers, called in question.

The third proper integument of the foetus is the *amnios*. It is thinner and firmer than the chorion; it has numerous ramifications of the umbilical vessels spread upon it, the lateral branches of which separate a liquor into its cavity. This is the proper liquor of the amnios: which at first is in a small quantity, afterwards increases for some months, then again decreases; and in a cow near her time, the quantity of this liquor is not above a pound. This membrane does not enter the *cornua uteri* in this creature, being confined to the body of the uterus; whereas the allantois occupies chiefly its cornua. But for what further relates to the structure of the involucra, with the nature of the liquors contained in them, I must refer to the second volume of Medical Essays, from page 121, where you have the sum of all I know of this matter.

There

There are here two *venæ umbilicales*, and but one in the human subject; because the extreme branches coming from the several placentulæ could not unite so soon as they would have done had they come all from one cake as in the human.

There is a small round fleshy body that swims in the urine of this creature, mares, &c. which is the *bipponæs* of the ancients. Several idle opinions and whims have been entertained as to its use; but that seems to be still unknown, or how it is generated or nourished, for it has no connection with the foetus or placentulæ.

Having thus considered the several involucra of this animal in a foetus state, let us next observe the specialities in its internal structure peculiar to a foetus.

The umbilical vein joins the *vena portarum* in the *capsula Glissoniana*, without sending off any branches as it does in the human subject. This vein soon after birth turns to a ligament; yet there are some instances where it has remained pervious for several years after birth, and occasioned a haemorrhage. We may next observe the duct called *canalis venosus*, going straight from the *capsula Glissoniana* to the *vena cava*; this turns also afterwards to a ligament. The umbilical arteries rise at acute angles from the internal iliacs, whatever some may say to the contrary; these also become impervious.

The pulmonary artery coming from the right ventricle of the heart divides into two; the largest, called *canalis arteriosus*, opens into the descending aorta; the other divides into two, to serve the lungs on each side. The *foramen ovale* is placed in the partition betwixt the right and left auricles. At the edge of the hole is fixed a membrane, which when much stretched will cover it all over; but more easily yields to a force that acts from the right auricle to the left, than from the left to the right. After what has been said, we may easily understand how the circulation is performed in a

fœtus. The blood, being brought from the placenta of the mother, is thrown into the *capsula Glissoniana*, where it is intimately blended with the blood in the *vena portarum*: then part of this blood goes directly into the *vena cava* by the *ductus venosus*; the rest passes through the liver. First, then, the whole is sent from the *vena cava* into the right auricle, from whence part of it is sent by the *foramen ovale* into the left auricle; the rest passes into the right ventricle, then into the pulmonary artery; then the greatest share it receives is sent immediately into the descending aorta by the *canalis arteriosus*, and the remainder circulates through the lungs, and is sent back by the pulmonary veins into the left auricle; which, with the blood brought there by the *foramen ovale*, is sent into the left ventricle, from whence it is driven by the aorta through the body. The great design of this mechanism is, that the whole mass of blood might not pass through the collapsed lungs of the fœtus; but that part of it might pass thro' the *foramen ovale* and *canalis arteriosus*, without circulating at all through the lungs.

This was the opinion that universally prevailed till the end of the last century, when it was violently opposed by Monsieur Mery, who is very singular in several of his opinions. He will not allow that the *foramen ovale* transmits blood from the right to the left auricle, but on the contrary from the left to the right; and that for no other reason but because he observed the pulmonary artery in a fœtus larger than the aorta. Mr Winslow endeavours to reconcile these two opinions, by saying the blood may pass either way, and that it is here as it were blended: his reason is, that on putting the heart in water, the *foramen ovale* transmits it any way. Mr Rohault, professor of anatomy at Turin, and formerly one of Mery's scholars, strongly defends his master, and criticises Mr Winslow. What he principally builds on, is the appearance this *foramen* has in some dried preparations: This Mr Wins-

flow will not allow as proof. After all, I remain in the common opinion ; and that for the following reasons : First, the pulmonary artery being larger signifies nothing, since its coats are not only thinner and will be more easily distended, but also the resistance to the blood in the pulmonary artery from the collapsed lungs is greater than the resistance to the blood in the aorta. Secondly, if we should allow any of these two uncommon opinions, we should have the right ventricle vastly more capacious than the left : For if we suppose the *foramen ovale* to be capable of transmitting one-third of the whole mass of blood in any given time, and the *canalis arteriosus* as much in the same time, then you will find, that, according to Mr Mery's opinion, the whole mass of blood being driven from the right ventricle into the pulmonary artery, one-third passes by the *canalis arteriosus* into the descending aorta, two-thirds passing through the lungs and returning into the left auricle ; one-half of which portion, or one-third of the whole mass, passes by the *foramen ovale* into the right auricle ; and the other, or the last third, will be sent into the left ventricle, and thence expelled into the *aorta* ; which third, with that from the pulmonary artery by the *canalis arteriosus*, circulating through the body, are returned unto the right auricle, where meeting with the other third from the *foramen ovale*, with it they are sent into the right ventricle to undergo the same course. Thus the whole mass is expelled by the right ventricle, and only one-third by the left. If this was the case, why is not the right ventricle three times as large and strong as the left ?

Then if, according to Mr Winslow's system, the *foramen ovale* transmits equal quantities from both auricles, this comes to the same as if there was no *foramen ovale* at all : that is to say, the whole mass going from the right auricle into the right ventricle and pulmonary artery, one-third of the whole mass passes into the aorta through the *canalis arteriosus* ; the other two-thirds,

passing through the lungs, return to the left auricle and ventricle. Thus the right ventricle expels the whole mass; the left, only two-thirds.

But if, according to the common opinion, we suppose the *foramen ovale* to convey the blood from the right to the left auricle, then one-third passes this way into the left ventricle; the other two-thirds are sent by the right ventricle into the pulmonary artery: from whence one-third passes by the *canalis arteriosus* into the *aorta descendens*; the other third circulates through the lungs, and is returned into the left ventricle; where meeting with that from the *foramen ovale*, it is therewith expelled into the aorta, and with the one-third transmitted by the *canalis arteriosus* returns into the right auricle to run the same race as before. Thus we conclude, that two-thirds are expelled by each ventricle, and the whole circulates through the body; and hence they come to be of pretty equal dimensions. In all this calculation I have had no regard to the blood discharged from the umbilical vessels; but the greater quantity returned by the veins, than sent out by the arteries, still argues for the common opinion.

The *kidneys* in the foetus are composed of different lobes, which serve to give us an idea of the kidneys being a congeries of different glands; these lobes being kept contiguous by the external membrane, are pressed by the other viscera, till at length they unite.

We now come to consider the creature as a ruminant animal. There are no *dentes incisores* in the upper jaw; but the gums are pretty hard, and the tongue rough. This roughness is occasioned by long sharp pointed papillæ, with which the whole substance of it is covered. These papillæ are turned towards the throat; so that by their means the food, having once got into the mouth, is not easily pulled back. The animals therefore supply the defect of teeth by wrapping their tongue round a tuft of grass; and so, pressing it against the upper jaw, keep it stretched, and cut it with the teeth

of the under jaw; then, without chewing, throw it down into the œsophagus, which in these creatures consists of a double row of spiral fibres decussating one another. All animals which ruminate must have more ventricles than one; some have two, some three; our present subject has no less than four. The food is carried directly down into the first, which lies upon the left side, and is the largest of all; it is called *γαστρ*, *ventriculus*, and *κοιλία*, by way of eminence. It is what is called by the general name of *paunch* by the vulgar. There are no rugæ upon its internal surface; but instead of these there are a vast number of small blunt-pointed processæ, by which the whole has a general roughness, and the surface is extended to several times the size of the paunch itself. The food, by the force of its muscular coat, and the liquors poured in here, is sufficiently macerated; after which it is forced up hence by the œsophagus into the mouth, and there it is made very small by mastication; this is what is properly called *chewing the cud*, or *rumination*; for which purpose the *dentes molares* are exceedingly well fitted: for instead of being covered with a thin crust, the enamel on them consists of perpendicular plates, between which the bone is bare, and constantly wearing faster than the enamel, so that the tooth remains good to extreme old age; and by means of these teeth the rumination is carried on for a long time without any danger of spoiling them. After rumination, the food is sent down by the gullet into the second stomach; for the œsophagus opens indifferently into both. It ends exactly where the two stomachs meet; and there is a smooth gutter with rising edges which leads into the second stomach, from thence to the third, and also to the fourth: however, the creature has a power to direct it into which it will. Some tell us, that the drink goes into the second; but that might be easily determined by making them drink before slaughter. The second stomach

stomach, which is the anterior and smaller, is called *πεκχυφαλος*, *reticulum*, *honeycomb*, the *bonnet*, or *king's-hood*. It consists of a great number of cells on its internal surface, of a regular pentagonal figure, like to a honeycomb. Here the food is farther macerated; from which it is protruded into the third, called *εχινος* or *omasum*, *vulgo* the *manyplies*, because the internal surface rises up into a great many plicæ or folds, and *stratum super stratum*, according to the length of this stomach. Some of these plicæ are farther produced into the stomach than others; *i. e.* first two long ones on each side, and within these two shorter in the middle, &c. There are numberless glandular grains like millet-seeds dispersed on its plicæ, from which some authors call this stomach the *millet*. From this it passes into the fourth, whose names are *κυνηρον*, *abomasum*, *caillè*, or the *red*, which is the name it commonly has because of its colour. This much resembles the human stomach, or that of a dog; only the inner folds or plicæ are longer and looser: and it may also be observed, that in all animals there is only one digestive stomach, and that has the same coagulating power in the foetus as the fourth stomach in this animal; whence this might not improperly be called the only true stomach. *Caillè* signifies *curdled*; and hence the French have given that as a name to this fourth stomach, because any milk that is taken down by young calves is there curdled. It is this fourth stomach, with the milk curdled in it, that is commonly taken for making runnet; but after the bile and pancreatic juice enter, this coagulation is not to be found, which shows the use of these liquors. There are other creatures which use the same food, that have not such a mechanism in their digestive organs. Horses, asses, &c. have but one stomach, where grass is macerated, and a liquor for their nourishment extracted, and the remainder sent out by the anus very little altered. From this different structure

ture of the stomach in these creatures, a ruminant animal will be served with one-third less food than another of equal bulk : graziers are sufficiently acquainted with this. The reason is, that ruminating animals have many and strong digestive organs ; all their food is fully prepared, and almost wholly converted into chyle : But a horse's stomach is not fitted for this ; so that he requires a much greater quantity of food to extract the same nourishment.

The guts of these creatures are of a considerable length in proportion to the bulk of the body ; and this confirms what we said formerly on the subject of the intestines of a dog, viz. that the length and capacity of the guts were different in different animals, according to the nature of their food.

The *duodenum* is formed here much the same way as in a dog, and the general intention kept in view with regard to the mixture of the bile and pancreatic lymph. The great guts here hardly deserve that name, their diameter differing very little from that of the small ones ; but to compensate this, they are much longer proportionally than a dog's are, being convoluted as the small guts are. The *cæcum* is very large and long. The digestion of the cow, as well as some other animals, is accompanied with a peculiar kind of action called *rumination* ; the intention of which seems to be, that the food may be sufficiently comminuted, and thus more fully acted upon by the stomach : for it is not observed that a calf ruminates as long as it is fed only upon milk, though the action takes place as soon as it begins to eat solid food. But it is to be observed, that as long as a calf feeds only upon milk, the food descends immediately into the fourth stomach (which, as has been already mentioned, seems only capable of performing the operation of digestion) without stopping in any of the first three. The rumination does not take place till after the animal has eaten

eaten a pretty large quantity : after which she lies down, if she can do it conveniently, and begins to chew ; though the operation will take place in a standing posture, if she cannot lie down. In this action a ball is observed to rise from the stomach with great velocity, almost as if shot from a musket. This ball the animal chews very accurately, and then swallows it again, and so on alternately, till all the food she has eaten has undergone this operation. This is easily explained from the structure of the œsophagus, which has one set of fibres calculated for bringing up the grafts, and another for taking it down again.

By means of rumination, the cow extracts a much larger proportion of nourishment from her food, than those animals which do not ruminant ; and hence she is contented with much worse fare, and smaller quantities of it, than a horse ; hence also the dung of cows, being much more exhausted of its fine parts than horse-dung, proves much inferior to it as a manure.

The *spleen* differs not much either in figure or situation from that of a dog's ; but it is a little more firmly fixed to the diaphragm, there not being here so much danger of this viscus's being hurt in the flexions of the spine.

The *liver* is not split into so many lobes in this creature as either in a man or dog ; which depends on the small motion this creature enjoys in its spine, which made such a division needless. This also confirms what I formerly advanced on this head.

Their *vesica urinaria* is of a pyramidal shape. It is very large, and more membranaceous ; for the urine of these creatures not being so acrid as that of carnivorous animals, there was no such occasion for expelling it so soon.

The male is provided with a loose pendulous *scrotum*, and consequently with *vesiculae seminales*. The female organs differ from those of a bitch, mostly as to the form of the cornua uteri, which are here contorted in

in form of a snail. In this, and all uniparous animals, they contain only part of the secundines; but in bitches, and other multiparous animals, they run straight up in the abdomen, and contain the foetus themselves.

The situation of the *heart* is pretty much the same with that of a dog, only its point is rather sharper: In us, the heart beating continually against the ribs, and both ventricles going equally far down to the constitution of the apex, it is very obtuse; but here the apex is made up only of the left ventricle, so is more acute.

The *aorta* in this creature is justly divided into *ascending* and *descending*, though this division is ill-founded either in a dog or man; and it has certainly been from this subject that the older anatomists took their descriptions when they made this division; for here the aorta divides into two, the ascending and descending.

### Of FOWLS in general.

THE next class of animals we come to consider are of the feathered kind; which are divided into the *granivorous* and *carnivorous*. But before we go on to consider the specialties in the viscera of each kind, we must observe what both species agree in.

Fowls have a particular covering of feathers different from all other creatures, but exactly well suited to their manner of life; for it not only protects them from the injuries of the weather, but serves them in their progression through that thin aerial element they are for the most part employed in; and as some fowls live much in the water, their feathers being continually besmeared with an oily liquor, keeps the water from soaking into their skins, and so prevents the bad effects which it would infallibly otherwise produce.

Fowls have the strongest muscles of their whole body inserted into their wings; whence by the way we may

may observe, that it is altogether impossible for man to buoy himself up into the air like birds, even though he had proper machines in place of wings, unless he were likewise provided with muscles strong enough for moving them, which he has not. In the next place, their wings are not placed in the middle of their bodies, but a good deal further forwards; whence it would at first view appear, that their heads would be erect, and their posterior parts most depending when raised in the air: but by stretching out their heads, which act upon the lever of a long neck, they alter their centre of gravity pretty much; and also by filling the sacs or bladders in the inside of their abdomen with air, and expanding their tail, they come to make the posterior part of their bodies considerably higher; and thus they fly with their bodies nearly in an horizontal situation. Hence we find, that if their necks are kept from being stretched out, or if you cut away their tails, they become incapable of flying any considerable way. The largeness of the wings in different fowls varies according to the occasions of the creature. Thus birds of prey, who must fly a considerable way to provide their food, have large strong wings; whereas domestic birds, who find their nourishment almost every where, have very short and but small wings. Their tail is of use in assisting to raise them in the air; though the chief purpose of it is to serve as a rudder in guiding their flight, whilst they use their wings as we do oars in putting forward a boat. The best account of this manner of progression of fowls is given by Alfonsus Borellus, in his treatise *De Motu Animalium*; and in the *Religious Philosopher* we have Borelli's doctrine stripped pretty much of its mathematical form. The posterior extremities are situated so far back, as to make us at first think they would be in continual hazard of falling down forwards when they walk: but this is prevented by their holding up their heads and necks, so as to make the centre of gravity fall upon the feet; and when

when they have occasion for climbing up a steep place, they stretch out their heads and necks forward, especially if they are short-legged, the better to preserve properly the balance of the body. Thus we may observe a goose entering a barn-door, where generally there is an ascending step, to stretch out its neck, which before was raised, and incline its body forwards. This is laughed at by the common people, who ascribe it to a piece of folly in the goose, as if afraid of knocking its head against the top of the door.

Carnivorous animals are provided with strong crooked claws for the catching their prey: water-fowls use them for swimming; and, principally for this purpose, have a strong firm membrane interposed betwixt the toes. There is a beautiful mechanism to be observed in the toes of fowls, which is of considerable use to them. For their toes are naturally drawn together, or bended, when the foot is bended: this is owing to the shortness of the tendons of the toes, which pass over them, which is analogous to our heel; and that the toes are set in the circumference of a circle, as our fingers are: Hence, when the foot is bended, the tendons must consequently be much stretched; and, since they are inserted into the toes, must of necessity bend them when the foot is bended; and when the foot is extended, the flexors of the toes are again relaxed, and they therefore expanded. This is also of great use to different kinds of fowls: thus the hawk descending with his legs and feet extended, spreads his talons over his prey; and the weight of his body bending his feet, the toes are contracted, and the prey is seized by the talons. This is also of great use to water fowls: for had there been no such contrivance as this, they must have lost as much time when they pulled their legs in as they had gained by the former stroke; but, as the parts are now framed, whenever the creature draws in its foot, the toes are at the same time bended and contracted into less space, so that the

resistance

resistance made against the water is not near so great as before : on the contrary, when they stretch their foot, their toes are extended, the membrane betwixt them expanded, and consequently a greater resistance made to the water. Again, such fowls as live mostly in the air, or have occasion to sustain themselves on branches of trees in windy weather, and even in the night-time when asleep, while all their muscles are supposed to be in a state of relaxation ; such, I say, have no more to do but lean down the weight of their bodies, and their toes continue bended without any muscles being in action ; and whenever they would disentangle themselves, they raise up their bodies, by which their foot, and consequently their toes, are extended. \*

The rostrum, bill, or beak of fowls, is composed of two mandibulæ, and, as in quadrupeds, the upper one has no motion but what it possesses in common with the head. But parrots are an exception to this rule ; for they can move the upper mandible at pleasure : this is exceeding convenient, as it enables them to lay hold of whatever comes in their way. Carnivorous fowls have their beaks long, sharp, and crooked ; the domestic fowls, such as the hen-kind, &c. have strong short beaks, commodiously fitted to dig up and break their food ; the water-fowls, again, have long or very broad scoop-like beaks, which is most convenient for them. The sternum of fowls is much larger proportionally than the human, and has a ridge rising in its middle for the more commodious origin of the muscles that move the wings. It is also less moveable than ours ; for had it been very moveable, a great deal of the force employed for moving the wings would at every contraction of the muscles have been lost, or else some other muscles must have come in play to keep firm the sternum ; but this additional weight would have been inconvenient for their progression.

What other things are most remarkable in the structure

ture of the several viscera, we shall consider in that common domestic animal the cock or hen, and afterwards observe the difference of their viscera chylopoietica from a carnivorous fowl.

### The ANATOMY of a COCK.

THOUGH this kind of birds live upon food somewhat similar to that of man, yet as they have no teeth to separate or break down this food, we would expect to find something to compensate for the want of teeth, something remarkable in the organs of digestion: we shall therefore begin with these parts.

The *œsophagus* of this creature runs down its neck, somewhat inclined to the right side; and terminates in a pretty large membranous sac, which is the *ingluvies* or crop, where the food is macerated and dissolved by a liquor separated by the glands, which are easily observed every where on the internal surface of this bag. The effect of this maceration may be very well observed in pigeons, who are sometimes in danger of being suffocated by the pease, &c. they feed upon, swelling to such an immense bulk in their *ingluvies*, that they can neither get upwards nor downwards. If it be a favourite fowl, it might be preserved by opening the sac, taking out the pease, and sewing up the wound.

The food getting out of this sac, goes down by the remaining part of the *œsophagus* into the *ventriculus succenturiatus*, or *infundibulum Peyeri*, which is a continuation of the gullet with more numerous glands, which separate a liquor to dilute the food still more, which at length get into the true stomach or gizzard, *ventriculus callosus*, which consists of two very strong muscles covered externally with a tendinous aponeurosis, and lined on the inside by a very thick firm membrane, which we evidently discover to be a production of the cuticula. This might have been proved in some measure *à priori*, from taking notice, that this mem-

brane, which in chicks is only a thin slight pellicle, by degrees turns thicker and stronger the more attrition it suffers: but there is no other animal-substance, so far as we know, which grows more hard and thick by being subjected to attrition, excepting the cuticula.—Hence may be drawn some kind of proof of what I have sometimes affirmed concerning the tunica vellosa of the stomach and intestines in the human body, viz. that it was in part a continuation of the epidermis; nay, all the hollow parts of the body, even arteries, veins, &c. seem to be lined with a production of this membrane, or one analogous to it. The use of the internal coat of the stomach of fowls is to defend the more tender parts of that viscus from the hard grains and little stones those creatures take down. The use of the gizzard is to compensate for the want of teeth; and it is well fitted for this purpose from the great strength it possesses.

The digestion of these animals is performed merely by attrition, as is evinced by many experiments; and it is further assisted by the hard bodies they swallow. We see them daily take down considerable numbers of the most solid rugged little flints they find; and these can serve for no other purpose than to help the trituration of their aliments\*. After these pebbles, by becoming smooth, are unfit for this office, they are thrown up by the mouth. Hence fowls that are long confined, though ever so well fed, turn lean for want of these stones to help their digestion. But this was put beyond all dispute by Mr Taurvry, who gave a species of metal to an ostrich, convex on one side, and concave on the other, but carved on both; and opening the creatures body some time after, it was found, that the carving on the convex side

was

\* Spallanzani has found, that pebbles are not at all necessary to the trituration of the food of these animals. He does not, however, deny, that when put in motion by the gastric muscles, they are capable of producing some effect on the contents of the stomach; but is inclined to believe, that they are not sought for and selected by design, as many suppose, but because they frequently happen to be mixed with the food. See Dissertations relative to the natural history of animals and vegetables.

was all obliterated, while the engraved character remained the same as before on the concave side, which was not subjected to the stomach's pressure: which could not have happened had digestion been performed by a menstruum, or any other way whatsoever; but may be easily solved by allowing a simple mechanical pressure to take place. We are, however, by no means to conclude from this, as some have too rashly done, that in the human body digestion is performed by simple attrition; otherwise we may, with equal strength of reason, by as good arguments drawn from what is observed in fishes, prove that the aliments are dissolved in our stomachs by the action of a menstruum. But this method of reasoning is very faulty; nor can it ever bring us to the true solution of any philosophical or medical problem. It is very plain, since the structure of the parts of the human stomach are so very different from that of this creature, that it is foolish and unreasonable to imagine both of them capable of producing the same effects. At each end of the stomach, there are as it were two particular sacs of a different texture from the rest of the stomach, not consisting of strong muscular fibres; they seem to be receptacles for the stones (especially at the end which is farthest from the orifice), while the digested aliment is protruded into the intestines.

The *duodenum* begins pretty near the same place at which the *œsophagus* enters; yet notwithstanding the vicinity of these two tubes, the aliments are in no danger of getting out before they are perfectly digested, by reason of a protuberance, or *septum medium*, betwixt the orifices; and in those creatures who have such a strong muscular stomach, it is a matter of great indifference whether the entry of the *œsophagus* or *pylorus* be highest, provided that the entry from the *œsophagus* does not allow the food to regurgitate, since the force of the stomach can easily protrude it towards the *duodenum*. This gut is mostly in the right side, and

hangs pendulous in their abdomen, having its two extremities fixed to the liver. The *ductus choledochus* enters near its termination, where it mounts up again to be fixed to the liver; and lest, by the contraction of the intestines, the bile should pass over without being intimately blended with the chyle, that duct enters downwards, contrary to the course of the food, and contrary to what is observed in any of the animals we have yet mentioned. But still the general intention is kept in view, in allowing these juices the fairest chance of being intimately blended with the food.

The *small guts* are proportionally longer than those of carnivorous birds, for the general cause already assigned. At the end of the ilium they have two large *intestina cæca*, one on each side, four or five inches long, coming off from the side of the rectum, and ascending; and we find them containing part of the food: These serve as reservoirs to the fæces; which, after some remora, there regurgitate into what soon becomes the rectum; which, together with the excretaries of urine and organs of generation, empties itself into the common cloaca. The small intestines are connected by a long loose mesentery, which has little or no fat accompanying the blood-vessels, there being no hazard of the blood's being stopped.

The *pancreas* in the creature lies betwixt the two folds of the duodenum, and sends two or three ducts into this gut pretty near the biliary.

The *spleen* is here of a round globular figure, situated between the liver and stomach; and betwixt these and the back-bone it enjoys the same properties as in other animals, viz. large blood-vessels, &c. All its blood is sent into the *vena portarum*, and has a perpetual conquaſſation. It has no excretory, as far as we know. Their *liver* is divided into two equal lobes by a pellucid membrane, running according to the length of their body: and hence we may observe, that it is not proper to that bowel to lie on the right side; which

is still more confirmed by what we observe in fishes, where the greatest part of it lies in the left side.

The shape of their *gall-bladder* is not much different from that of quadrupeds; but is thought to be longer in proportion to the size of the animal, and is farther removed from the liver.

The principal difference to be remarked in their *heart*, is the want of the *valvulae tricuspides*, and their place being supplied by one fleshy flap.

The *lungs* are not loose within the cavity of the thorax, but fixed to the bone all the way; neither are they divided into lobes, as in those animals that have a large motion in their spine. They are two red spongy bodies, covered with a membrane that is pervious, and which communicates with the large vesicles or air-bags that are dispersed over their whole abdomen; which vesicles serve two very considerable uses. The one is to render their bodies specifically light, when they have a mind to ascend and buoy themselves up when flying, by distending their lungs with air, and also straiten their *trachæa arteria*, and so return the air. Secondly, they supply the place of a muscular *diaphragm* and strong abdominal muscles; producing the same effects on the several contained viscera, as these muscles would have done, without the inconveniency of their additional weight; and conduced as much to the exclusion of the egg and faeces.

When we examine the upper end of the *tracheæ*, we observe a *rima glottidis* with muscular sides, which may act in preventing the food or drink from passing into the lungs; for there is no *epiglottis* as in man and quadrupeds.

The *trachea arteria*, near where it divides, is very much contracted; and their voice is principally owing to this coarctation. If you listen attentively to a cock crowing, you will be sensible that the noise does not proceed from the throat, but deeper; nay, this very pipe, when taken out of the body, and cut off a little

after its division, and blown into, will make a squeaking noise, something like the voice of these creatures. On each side, a little higher than this contraction, there is a muscle arising from their sternum, which dilates the trachea. The cartilages, of which the pipe is composed in this animal, go quite round it; whereas in men and quadrupeds they are discontinued for about one-fourth on the back part, and the intermediate space is filled up by a membrane. Neither is the trachea so firmly attached to their vertebræ as in the other creatures we have examined. This structure we shall find of great service to them, if we consider, that, had the same structure obtained in them as in us, their breath would have been in hazard of being stopped at every flexion or twisting of their neck, which they are frequently obliged to. This we may be sensible of by bending our necks considerably on one side, upon which we shall find a great straitness and difficulty of breathing; whereas their trachea is better fitted for following the flexions of the neck by its loose connection to the vertebræ.

In place of a *muscular diaphragm*, this creature has nothing but a thin membrane connected to the pericardium, which separates the thorax and abdomen. But besides this, the whole abdomen and thorax are divided by a longitudinal membrane or *mediastinum* connected to the lungs, pericardium, liver, stomach, and to the fat lying over their stomach and guts, which is analogous to an *omentum*, and supplies its place.

The *lymphatic system* in birds consists, as in man, of lacteal and lymphatic vessels, with the thoracic duct.

The lacteals indeed, in the strictest sense, are the lymphatics of the intestines; and, like the other lymphatics, carry only a transparent lymph; and instead of one thoracic duct, there are two, which go to the jugular veins. In these circumstances, it would seem that birds differ from the human subject, so far at least as we may judge from the dissection of a *goose*, the common

mon subject of this inquiry, and from which the following description is taken.

The lacteals run from the intestines upon the mesenteric vessels : those of the duodenum pass by the side of the pancreas ; afterward they get upon the cæliac artery, of which the superior mesenteric is a branch. Here they are joined by the lymphatics of the liver, and then they form a plexus which surrounds the cæliac artery. Here also they receive a lymphatic from the gizzard, and soon after another from the lower part of the œsophagus. At the root of the cæliac artery they are joined by the lymphatics from the glandulæ renales, and near the same part by the lacteals from the other small intestines, which vessels accompany the lower mesenteric artery ; but, before they join those from the duodenum, receive from the rectum a lymphatic, which runs from the blood-vessels of that gut. Into this lymphatic some small vessels from the kidneys seem to enter at the root of the cæliac artery. The lymphatics of the lower extremities probably join those from the intestines. At the root of the cæliac artery and contiguous part of the aorta, a net-work is formed by the vessels above described. From this net-work arise two thoracic ducts, of which one lies on each side of the spine, and runs obliquely over the lungs to the jugular vein, into the inside of which it terminates, nearly opposite to the angle formed by the vein and this subclavian one. The thoracic duct of the left side is joined by a large lymphatic, which runs upon the œsophagus. The thoracic ducts are joined by the lymphatics of the neck, and probably by those of the wings where they open into the jugular veins. The lymphatics of the neck generally consist of two large branches, on each side of the neck, accompanying the blood-vessels ; and these two branches join near the lower part of the neck, and form a trunk which runs close to the jugular vein, and opens into a lymphatic gland ; from the opposite

side of this gland a lymphatic comes out, which ends in the jugular vein.

On the left side, the whole of this lymphatic joins the thoracic duct of the same side : but, on the right one, part of it goes into the inside of the jugular vein a little above the angle ; whilst another joins the thoracic duct, and with that duct forms a common trunk, which opens into the inside of the jugular vein, a little below the angle which that vein makes with the sub-clavian. This system in birds differs most from that of quadrupeds, in the chyle being transparent and colourless, and in there being no visible lymphatic glands, neither in the course of the lacteals, nor in that of the lymphatics of the abdomen, nor near the thoracic ducts.

The kidneys lie in the hollow excavated in the side of the back-bone, from which there is sent out a bluish-coloured canal running along by the side of the *vas deferens*, and terminating directly into the common cloaca. This is the *ureter*, which opens by a peculiar aperture of its own, and not at the penis. Fowls having no *vesica urinaria*, it was thought by some they never passed any urine, but that it went to the nourishment of the feathers : but this is false ; for that whitish substance that you see their greenish fæces covered with, and which turns afterwards chalky, is their urine. Let us next consider the organs of generation of both sexes, and first those of the male.

The *testicles* are situated one on each side of the back-bone ; and are proportionally very large to the creature's bulk. From these run out the *vasa seminifera* ; at first straight ; but after they recede farther from the body of the testicle, they acquire an undulated or convoluted form, as the epididymis in man. These convolutions partly supply the want of *vesiculae seminales*, their coition being at the same time very short : These terminate in the penis, of which the cock has two, one on each side of the common cloaca,

point-

pointing directly outwards. They open at a distance from each other, and are very small and short; whence they have escaped the notice of anatomists, who have often denied their existence. In birds there is no prostate gland. This is what is chiefly remarkable in the organs of the male.

The *racemus vitellorum*, being analogous to the ovaria in the human subject, are attached by a proper membrane to the back-bone. This is very fine and thin, and continued down to the uterus. Its orifice is averse with respect to the ovaria; yet notwithstanding, by the force of the *orgasmus venereus*, it turns round and grasps the *vitellus*, which in its passage through this duct called the *infundibulum*, receives a thick gelatinous liquor, secreted by certain glands. This, with what it receives in the uterus, composes the white of the egg. By this tube then it is carried into the uterus. The shell is lined with a membrane; and in the large end there is a bag full of air, from which there is no outlet.

The *uterus* is a large bag, placed at the end of the *infundibulum*, full of wrinkles on its inside; here the egg is completed, receiving its last involucrum, and is at last pushed out at an opening on the side of the common cloaca. From the testes in the male being so very large in proportion to the body of the creature, there must necessarily be a great quantity of semen secreted; hence the animal is salacious, and becomes capable of impregnating many females. The want of the *vesiculae seminales* is in some measure supplied by the convolutions of the *vasa deferentia*, and by the small distance betwixt the secreting and excretory organs. The two *penes* contribute also very much to their short coition; at which time the opening of the uterus into the cloaca is very much dilated, that the effect of the semen on the vitelli may be the greater.

A hen will of herself indeed lay eggs; but these are

are not impregnated, and yet appear entirely complete.

I come now to consider the nutrition of the foetuses of oviparous animals, and shall give a short history of an egg, and of the changes brought on it by incubation. To save the perpetual repetition of my being assured of the truth of each fact by repeated observations, I have to observe once for all, that unless where I expressly confess I had no opportunity, or neglected to examine them, I consider myself obliged to give ocular demonstration of what I assert.

1. The shell of an egg becomes more brittle by being exposed to a dry heat.

2. The shell is lined every-where with a very thin, but pretty tough, membrane; which, dividing at or very near to the obtuse end of the egg, forms a small bag, where only air is contained.

3. In a new-laid egg, this folliculus appears very little, but becomes larger when the egg is kept.

4. The albumen, or white of an egg, is contained in concentrical membranes, but is not all of the same consistence: for the exterior part of it is thin, and diffuses itself almost like water when the membranes are broken; whereas its anterior part is more viscous.

5. The white of an egg can make its way through the shell, as appears from its wasting by keeping, especially if it is exposed to gentle heat.

6. The globular vitellus or yolk would seem to be no other than a liquor inclosed in a membrane; because, whenever the membrane is broke, it runs all out; and it is specifically heavier than the white.

7. The chalazæ are two white spongy bodies, rising very small from opposite sides of the membrane of the yolk, but gradually become larger as they are stretched out from it in an oblique direction with regard to the two ends of the egg.

8. If we compare the chalazæ to the extremities of an axis passing through the spherical vitellus, this sphere will

will be composed of two equal portions, its axis not passing through its centre; consequently, since it is heavier than the white, its smaller portion must always be uppermost in all positions of the egg.

9. The yellowish-white round spot, called *cicatricula*, is placed on the middle of the smaller portion of the yolk; and therefore must (by § 8.) always appear on the superior part of the vitellus.

10. The cicatricula seems to be composed of several circles of different colours; and, in a fecundated egg, contains the embryo or chick. See Malpighi \*.

11. Eggs, whose obtuse ends are all rubbed over with linseed-oil, or such other substances as block up small pores, are as fit for bringing forth chickens, when incubated by a hen, as other eggs are.

I did not make the experiment; but can give a voucher, whose scrupulous candour, with sincere good wishes and endeavours for the improvement of physic in this place, numbers must be acquainted with: I mean my father; who besmeared eighteen eggs in the manner mentioned; then having put a mark on them, he set them, with the like number of other eggs, under three hens, who brought out thirty-six chickens, not one egg of the whole number failing.

12. After incubation, the *folliculus aëris* is gradually extended; till, near the time of the exclusion of the chick, it occupies, as near as I could judge, some more than a third of the cavity of the shell.

13. The extended folliculus does not collapse, upon being exposed to the pressure of the atmosphere after incubated eggs are opened †.

#### 14. By

\* De Ovo Incubat.

† It is somewhat out of my sphere to inquire how this additional air gets into the folliculus: but if any are curious enough to make this inquiry, I would recommend to them to observe how this folliculus distends and keeps stretched in an exhausted receiver of an air-pump; to exhaust the air gradually out of the shell, while it stands exposed to the atmosphere, both while the folliculus is entire, and after it is broke, observing always the rising or falling of the mercurial gage; to consider § 11. and 13.; and to consult Bellini de mot. cord. prop. ix. and Hale's Staticks.

14. By incubation the albumen becomes thinner and more turbid, especially on its upper part near to the air-bag, where it is also first consumed : and it is afterwards diminished towards the sharp end of the egg, till at last nothing of it is left except a white cretaceous substance at the lower part of the shell.

15. As the part of the white nearest to the cicatricula is wasted, its membrane and the cicutricula still approach nearer, till they become contiguous. This membrane of the albumen is what is commonly called the *chorion*.

16. Some time before the albumen is quite consumed, what remains of it is placed at the lower part of the egg ; and therefore the yolk is interposed betwixt it and the membrane which immediately contains the foetus. See § 9. and 10.

17. The white of a fecundated egg is as sweet and free from corruption, during all the time of incubation, as it is in a new-laid egg.

I tasted, smelted, and swallowed the whites of eggs during all the states of incubation, both when they were raw and boiled, and constantly found it as just now described ; and therefore cannot imagine how Bellini \* could affirm it to have a heavy, abominably ungrateful taste, a stinking smell, and not only to occasion, when swallowed, a troublesome sensation in the stomach and guts, but to prove purgative. He must unluckily have examined none but subventaneous eggs : which is further confirmed by his description of the small particles in the colliquated albumen, that reflect light so strongly as the eye cannot bear it ; which I saw in some subventaneous eggs, but could not observe in any that were impregnated.

18. According to Bellini †, the colliquated white always becomes incapable of coagulation by heat ; but in the trials I made, it frequently did coagulate, though

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\* De Motu Cord. prop. vi.

† Ibid.

I found the success of this experiment very uncertain : the only general rule I could fix was, that, before the 9th or 10th day of incubation, the thinner white did not generally coagulate ; but after that, it frequently did.

19. Very soon after incubation, the volume of the yolk appears increased ; and, by its rising then nearer to the upper part of the egg, one may conclude that its specific weight decreases.

20. The yolk becomes pale and more fluid for some time, especially on the side next to the chick, where its bulk also soonest increases ; but afterwards the membranes of the yolk turn firmer and stronger, and the liquor in them is less in quantity, and becomes more viscous.

21. As the chick increases, the yolk is depressed in the middle ; and is soon brought into a form something like to a horse-shoe, in the middle of which the chick is lodged.

22. The yolk remains fresh and uncorrupted all the time of incubation, and is always coagulable.

23. Not long before the exclusion of the chick, the whole yolk is taken into its abdomen.

24. The whole albumen and vitellus are not consumed by the chick : for some part of the humours of the egg escapes through the shell, and is not supplied by any thing from without ; as evidently appears by an egg's becoming so much specifically lighter, as to swim in water after incubation, though it sunk in it when recent.

25. The chalazæ remain long without being considerably changed, unless that they are brought nearer to each other by the crescent form of the yolk ; at last they degenerate into a dry chalky substance.

26. The cicatricula very soon is enlarged by incubation ; and, being buoyed up on the top of the yolk to the superior part of the egg, it is placed very near to the air-bag ; and when both increase, they become contiguous.

27. The

27. The cicatricula is called *amnios*, when it becomes large, and contains the colliquamentum or liquor in which the chick is immersed.

28. The quantity of the colliquamentum gradually increases till the 15th or 16th day of incubation; on the 18th, it is all consumed; and, in the three following days, scarce any moisture can be observed on the internal surface of the amnios.

29. The liquor of the amnios is more clear and transparent than the colliquated white; its taste is more salt, and it has no observable smell. Its consistence is at first a little viscous, then it becomes more fluid, and afterwards turns a littleropy again.

N. I can say nothing of the particular times when it does or does not coagulate by heat: for it is in so small quantity during the greater part of the time of incubation, that one can scarce gather as much in a spoon as is fit to make any experiment with; and when all the egg is boiled hard, it adheres so closely to the white, that it is scarce possible to distinguish one from the other. Malpighius\*, speaking of the egg between the 14th and 19th day, says, "That this thin diaphanous liquor of the amnios was sometimes forced, by boiling, into a white tasty substance;" which my trials also confirmed.

30. The allantois and its contained urine are to be seen in an egg, as well as in the secundines of viviparous animals†.

31. Though the heart is among the first parts of the chick that can be distinguished, yet the umbilical vessels are seen much about the same that the heart is observed.

I did not inquire into this fact; but have two very good vouchers for its truth, Harvey‡ and Malpighius§.

32. The umbilical vessels gradually disperse their  
I    branches

\* De Ovo Incubato.

† Malpig. Append. de Ovo Incub. tab. vii.

‡ De Generat. Animal. exercit. 16. and 17.

§ De Ovo Incubato.

branches upon the amnios, upon the vitellus, and upon the membranes of the albumen: The extremities of the much greater number, being immersed into the white, are extended proportionally as it is colliquated.

33. Near to the end of incubation, the umbilical vessels begin to shrivel and decrease, till at the exclusion they are very small.

34. The embryo is seen in an egg at first in form of a small worm: then its carina or spine, with the large prominences, that afterwards show themselves to be the brains and eyes, appear; the other bowels seem hanging from the spine; the chasm of the mouth discovers itself; the extremities sprout out; the viscera are gradually covered with the teguments; and at last the beak, nails, and feathers are seen: after which all the parts become stronger and firmer, the proportional bulk of the head decreasing.

For the particular times when all these changes are thus orderly brought about, consult Fabric. ab Aquapendente, Harvey, and Malpighius.

35. After all the parts of the chick are formed, it is always found lying on its side, with its neck greatly bended forward, the head being covered with the upper wing, and the beak placed between the thighs.

36. When the shell is opened after the chick is large and strong, it may be seen to bounce and spurn, sometimes opening its mouth wide, especially if it is stirred or pricked.

37. The mouth, œsophagus, and ingluvies, are always found moist; but never contain any quantity of liquor that can be collected or will run out in drops.

38. The bulbous glandular part of the œsophagus immediately above the stomach, or what Peyer \* calls the *infundibulum*, and the stomach, are full of a liquor, in the youngest chick we can dissect, and continue full the whole time of incubation; neither infundibulum nor stomach having yet got the tendinous firmness they have

\* Comment. in Anat. Ventricul. Gallin.

have in adults; nor can we observe the dry pellicle which is so easily separated from these parts in hens.

39. This liquor of the stomach is at first thin and more watery; afterwards it becomes curdy; and at last is all in form of a greyish white mucus, unless that some part of it frequently is coloured yellow or green by a mixture of bile. It always coagulates, by boiling, into a firm yellowish white substance.

40. The quantity of faeces was not large in the great guts of any chickens I opened before exclusion.

41. A little time before the exclusion, the chick may frequently be heard making the same piping sound that hatched chickens make. In three eggs, which were all I opened in this state, the beak of the chick had perforated the membrane of the *folliculus aëris*.

42. The shell at the obtuse end of the egg frequently appears cracked some time before the exclusion of the chick.

43. The chick is sometimes observed to perforate the shell with its beak; but, in those I saw tumbling out of the shell, it was broke off irregularly, at the place where the membrane of the *folliculus aëris* was joined to it.

44. After the exclusion of the yolk is gradually wasted, being conveyed into the small guts by a small duct, its membranes gradually contract themselves, and the duct becomes shorter. On the tenth day after exclusion, the vitellus was no larger than a small pin-head, and the duct was scarce one-twentieth part of an inch long.

From this history of the egg and of incubation, I shall endeavour to deduce the manner in which the colliquated white is taken in by the chick.

Authors generally seem to agree, that the oviparous foetus, while very young, receives its nourishment by the navel; but several of the best reputation have been of opinion, that afterwards it is conveyed by the mouth.

\* De Mot. Cord. prop. ix.

I shall examine the arguments they used in proof of this, and then shall subjoin some negative reasons which they have not taken notice of.

Bellini\* has described the cicatricula, or *sacculus amnii*, with the chalazæ first formed in the back of the hen; to which, according to him, the vitellus is afterwards joined, and the white is acquired as they tumble down the oviduct. He says the chalazæ are composed of numerous canals, which open into the amnios, and send out their roots into the cavity of the yolk, and into the white. It is easy to conceive what consequences may be drawn from this description, by those who assert the nourishment to be carried by the mouth, viz. That here are direct passages into the cavity where the chick is, which can take up the liquors no other way than by the mouth.

The answer to this observation is the same as has been made to the other facts already quoted from this author. I deny that the *sacculus amnii* is formed before the vitellus; on the contrary, the vitellus is evidently to be seen before the cicatricula or chalazæ can be discerned. Next, I deny the chalazæ (if they are canals) to have the least communication with the amnios, at any time, or in any state of the egg, otherwise than as they are both adhering to the membrane of the vitellus; upon which, or within which, no particular fibres, no canals, are stretched to the cicatricula. Every one has it in his power to examine these facts. If then the facts are denied, the consequences cannot be admitted.

Since there are no canals passing through the yolk, that open into the *saccus colliquamenti*, and the cicatricula comes to be placed on the upper part of the yolk, and contiguous to the air-bag (§ 26.), it is evident, that the *liquor amnii* must be furnished by the chicken, which being covered with feathers, having no mammæ, bladder of urine, or large salivary glands, can only sup-

\* De Mot. Cord. prop. ix.

ply it by the branches of the umbilical vessels spread on the amnios.

Harvey\* affirms, that a liquor is found in the mouth and ingluvies of the chick, which he concludes to be the colliquamentum or *Liquor amnii*, from their resemblance; from the quantity of the contents of the stomach; from the chick's being seen to open its mouth; and from the necessity creatures are in of swallowing, or of forcing back by vomiting, whatever is introduced to the root of their tongue.

As to the resemblance, I do not see how the comparison can be made, seeing the liquor in the mouth and crop is in such small quantity, (§ 37.) But suppose that a sufficient quantity was collected, the two liquors agreeing in several properties would not of itself be a sufficient proof of their being the same; and if, for argument's sake, the liquor in the crop was granted to be in very large quantity, and to agree in every property with that in the amnios, it would certainly appear in the same form for some time in the stomach; whereas it is always found very different there in the larger foetus (§ 39); and Harvey confesses as much in this place: therefore it may be concluded, that it does not go down into the stomach.

If ever any thing like faeces has been seen in the crop of chickens, as has been alleged by some, it might be no more than the yellow or green-coloured substance brought up from the stomach, (§ 39.)

The quantity of the contents of the stomach and intestines may be accounted for from § 38. applied to what was said on viviparous animals.

Though creatures that respire are under a necessity of either swallowing, or forcing back by vomiting, whatever is introduced beyond their fauces, I cannot think it should be thence concluded that a foetus is under the same necessity: for, as it does not exercise respiration, it will suffer no inconvenience by a liquor lodging

\* De Generat. Animal. exercit. 58.

lodging near to the glottis; whereas creatures that breathe cannot allow any substance to remain there without danger of the glottis being stopped, or of such substances falling down the trachæa, either of which would be of bad consequence; which the creature prevents, by forcing such substances out of such a dangerous situation.

But, to enforce the negative of the *colliquamentum* passing by the mouth, observe, that there are only three days in which this passage can most probably be supposed to happen, which are from the 15th to the 18th day of incubation: for before the 15th, the quantity of the *liquor amnii* is increasing, which is no great sign of its being swallowed; and after the 18th this liquor is not to be seen, (*vid. § 28.*) If, then, the *liquor amnii* were all swallowed between the 15th and 18th days, the stomach ought to be fuller at this time, and its contents should be thinner, more pellucid, &c. like to the *colliquamentum*; which I am certain does not happen. Besides, if we suppose the power of digestion so strong as to expel this liquor as fast as it is taken down in these three days, it would certainly follow, that this powerful digestion continuing in the three succeeding days, while there is no liquor to be swallowed, the stomach ought to be quite emptied; which every one who opens the stomachs of chickens at this time will see it is not. And, lastly, as a more direct proof still against Harvey, I broke the shells of several incubated eggs, while the *colliquamentum* was in large quantity; and before the amnios was opened, I saw the chickens open their mouths very wide several times, but could not observe the quantity of the liquor in which they lay any way lessened. I afterwards carefully dissected the chickens, and found no other than the common small quantity in the crops, and the ordinary curdy mucus in the stomach; which seems to me a demonstration that they do not swallow.

After such convincing proofs, it will be needless to  
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make any application of the arguments in the former part of this essay to this subject ; and therefore I shall only desire the reader to compare the posture of a chick, and of a hen while she swallows liquors, that they may see the posture of the chick's neck to be most unfavourable to the supposition of deglutition being performed ; and then shall conclude with a very short history of incubation, assigning what I imagine to be the most probable reasons of the several appearances.

By the heat of the hen, or of stoves equal to it, assisted possibly by the action of the air contained in the *folliculus aëris* (§ 2. 3. 12.), the albumen becomes thinner, especially where it is most exposed to these forces (§ 14.) ; and the vitellus in the same manner becomes specifically lighter (§ 19.), and therefore readily rises in the white. And as, by being divided into two unequal portions by its axis the chalazæ, it presents the smaller portion to the incubating heat at first, (§ 8. 9.) ; so the change in consequence of incubation being soonest and most produced here (§ 20.), and the cicatricula being enlarged at the same time, the smaller portion of the yolk becomes of the least specifical weight ; and therefore is buoyed up to the superior part of the egg ; whereby the *folliculus aëris* and membranes of the cicatricula become contiguous when they enlarge (§ 26.), and the vitellus can never be in hazard of compressing the tender embryo ; and the umbilical vessels are situated so as to have their extremities immersed in the liquors that first undergo the proper change, for being imbibed by their orifices, (§ 32.)—The incubation continuing, the white is still more and more colliquated, and the umbilical vessels are proportionally extended, the veins to absorb it, and the arteries to throw out any particles that are unfit for the chick till they are farther prepared, but especially to drive forward the liquors in the veins, as was explained in the account of the viviparous animals, (§ 20.)—When the white in the upper part of the egg is exhausted, its membranes become

come contiguous to the amnios, (§ 15.) ; and thereby the membranes involving the foetus, become sufficiently strong to resist the motions of the chick, when its ease or safety prompt it at any time to spurn.—The powers of incubation above-mentioned, assisted by the pulsation and conquassatory motions of the numerous umbilical vessels spread on the yolk (§ 32.), dissolve that humour more, and render some part of it fine enough to be taken up by the small extremities of the umbilical vein, some of which penetrate its membrane: by which the liquor at last becomes thicker (§ 20.) ; and the membrane, being in part emptied, will more easily yield to the weight of the chick ; and is pressed into the form of a horse-shoe (§ 21.), while the network of vessels extended on this membrane renders it stronger and firmer.—The *folliculus aëris* not only assists in colliquating the albumen ; but, when the humours of the egg come to occupy a less space, by escaping through the shell (§ 24.), and by being changed into the solid substance of the chick, the folliculus enlarging (§ 12.), keeps the chick and humours steady, without danger of being disordered and broke by the motions of the egg.—Branches of the umbilical vessels being distributed to the amnios (§ 32.), the arteries will pour out their liquors into its cavity in greater quantity than the veins can take them up, as long as the foetus is weak ; but whenever the foetus becomes stronger, and consequently the absorbent power of the veins increases, they will take up the fluid of the amnios faster than the arteries pour it in, and its quantity will be diminished till it is quite exhausted, (§ 28. and 29.)—This absorption will go on more speedily in proportion also to the umbilical vessels being less distended with albumen, whereby there is less resistance to the progressive motion of the absorbed liquors ; which probably is the reason of the colliquamentum being all taken up between the 15th and 18th days.—By the constant circulation and renewal of all these humours of

the egg, they keep fresh and uncorrupted in a fecundated egg, (§ 17. and 22.) but corrupt soon in a subventaneous one, or in such whose foetus dies in the time of incubation.—Wherever vessels are not sufficiently filled, they contract themselves; and therefore the albumen being exhausted in the last days of incubation, the umbilical vessels gradually shrivel (§ 33.), which prevents the danger of an haemorrhage when the chick is separated from its membranes. But as the white is not sufficient at this time fully to supply the chick, the yolk is taken into its body, (§ 23.) and being there pressed, it is thrown gradually by the proper duct (§ 23. and 44.) into the guts, to supply that defect.—The vessels and glands which open into the alimentary tube separate at least as much liquor as will moisten it; and the stomach, having no callous strong crust on its internal surface (§ 38.), will separate more than it can do in the adult; and in the mean time the glands of the infundibulum pour out a liquor that is always thicker as the chick increases, till it becomes a very thick white mucus: And therefore the contents of the stomach of the foetus in the egg must have the appearance described (§ 39.), and will be slowly passing off into the intestines.—The shell at the obtuse end of the egg becoming more brittle, by being so long exposed to a dry heat (§ 1.), and the membranes losing their toughness when their moisture is exhausted, the chick very easily tears them, and breaks off that end of the shell, to make its way into the common atmosphere.—The mother having no juices prepared within her body to give to the chick for food after it is hatched, and its organs for taking in and digesting aliment being for some time too weak to supply it sufficiently with nourishment, the vitellus is made to supply these deficiencies, till the chick is sufficiently confirmed and strong (§ 44.); after which it is no longer the subject of my present inquiry.

After

After having observed the contents of the abdomen and thorax, we next proceed to examine the parts about the neck and head.

These creatures, as was observed of fowls in general, have no teeth. Some, indeed, have an appearance of teeth; but these are only small processes or ferræ rising out from the mandible, without any socket, &c. which would have been needless, as they swallow their food entire. But their tongue is made pretty firm, lest it should be hurt by the sharp points of the grain they feed on. It is of a triangular figure, and pointed before; and as by their depending posture their meat is in hazard of falling out of their mouths, to prevent this there are several small pointed papillæ standing out upon their tongue and palate, with their points inclined backwards, allowing an easy passage to the food, but hindering it to return.

We have here no *velum palatinum, uvula, or epiglottis*; and in place of two large holes opening into the nose, there is only a long narrow rima supplied with pretty strong muscles, and such another supplies the place of a glottis. The creature has a power of shutting both at pleasure; and the nature of their food seems not only to exempt them from the hazard of its getting into the nose or trachea, but its sharp points would hurt an uvula, or epiglottis, if they had any. Hence we see with what difficulty they swallow dough or other sort of food that can be easily moulded into any form. When we examine the upper end of the trachea, we observe a rima glottidis with muscular sides, which may act in preventing the food or drink from passing into the lungs, for there is no epiglottis as in man and quadrupeds.

Their cranium is more cellular and cavernous than ours. By this means their heads are light, yet strong enough to resist external injuries; for the enlarging the diameter of bones contributes to their strength. By this cavernous cranium the organ of smelling is

supposed to be considerably enlarged ; and further, singing birds, as is observed by Mr Ray and Mr Dernham, have this cavernous structure of the brain still more observable : and we are told that the cavity of the tympanum communicates with the cells : but this, I am apt to believe, so far as I could find from dissection, is rather founded on theory than matter of fact. Their brain is covered with the common membranes, but its external surface is not formed into so many gyrae or convolutions as ours. Its anterior part is quite solid, of a cineritious colour, and so far has a resemblance of the *corpora striata* as to give rise to the olfactory nerves. The whole of it appears to us as imperfect, and we can scarce determine whether there be any thing analogous to a third or fourth ventricle : neither the *corpus callosum*, *fornix*, *nates*, or *testes*, &c. can be observed here ; which parts therefore cannot be imagined as absolutely necessary for the functions of life, since we find these creatures perform them sufficiently well. We may perhaps think these serve a particular use in man, who is a rational creature ; but then quadrupeds enjoy them in common with men. These protuberances, &c. seem rather to depend on the different disposition of the several parts, being variously connected and meeting in different directions in different places, than their being absolutely necessary for any particular use ; and the uses that have been assigned to different parts of the brain by authors, seem to me to have no foundation but in the author's fancy. I have already owned my ignorance of the uses of the particular parts of the brain, so shall not pretend to give reasons for their being different in different animals ; but all seem to agree in this, that the cerebrum has always hollows and vacuities in it.

Their organ of smelling is very large, and well provided with nerves ; hence they have this sensation very acute. Ravens and other birds of prey give a sure proof of this, by their being able to find out their prey, though

though concealed from their sight and at a considerable distance.

Those birds that grope for their food in the waters, mud, &c. have large nerves, which run quite to the end of their bills, by which they find out and distinguish their food.

The anterior part of their *eyes* (instead of having the sclerotic coat contained, so as to make near a sphere as in us) turns all of a sudden flat; so that here the sclerotic makes but half a sphere; and the cornea rises up afterwards, being a portion of a very small and distinct sphere: so that in these creatures there is a much greater difference betwixt the sclerotic and cornua than in us. Hence their eyes do not jut out of their heads, as in man and quadrupeds. As most of these creatures are continually employed in hedges and thickets, therefore, that their eyes might be secured from these injuries, as well as from too much light when flying in the face of the sun, there is a very elegant mechanism in their eyes. A membrane rises from the internal canthus, which at pleasure, like a curtain, can be made to cover the whole eye; and this by means of a proper muscle that rises from the sclerotic coat, and passing round the optic nerves, runs through the *musculus oculi attolens* (by which however the optic nerves are not compressed) and palpebra, to be inserted into the edge of this membrane. Whenever this muscle ceases to act, the membrane by its own elasticity again discovers the eye. This covering is neither pellucid nor opake, both which would have been equally inconvenient; but, being somewhat transparent, allows as many rays to enter as to make any object just visible, and is sufficient to direct them in their progression. By means of this membrane it is that the eagle is said to look at the sun. Quadrupeds also, as we mentioned before, have a small *membrana nictitans*.

Besides, all fowls have another particularity, the use of which I think is not so well understood; and that is,

is, a pretty long black triangular purse, rising from the bottom of their eye just at the entry of the optic nerve, and stretched out into their vitreous humour, and one would imagine it gave some threads to the crystalline. To this the French (who, as far as I know, were the first who took notice of it in their dissections before the Royal Academy) gave the name of *bourse noire*. This may possibly serve to suffocate some of the rays of light, that they may see objects more distinctly without hurting their eyes. It has a connection with the vitreous, and seems to be joined also to the crystalline, humours. If we suppose it to have a power of contraction, (which may be as well allowed as that of the iris), it may so alter the position of the vitreous and crystalline humours, that the rays from any body may not fall perpendicularly upon the crystalline; and this seems to be necessary in them, since they cannot change the figure of the anterior part of their eye so much as we can do: and as this animal is exposed often to too great a number of rays of light, so they have no tapetum, but have the bottom of their eye wholly black on the retina; and in consequence of this, fowls see very ill in the dark.

They have no external ear; but in place thereof a tuft of very fine feathers covering the *meatus auditorius*, which easily allows the rays of sound to pass them, and likewise prevents dust or any insect from getting in. An external ear would have been inconvenient in their passing through thickets, and in flying, &c. A liquor is separated in the external part of the ear, or *meatus auditorius*, to lubricate the passage, and further prevent the entrance of any insects, &c. The *membrana tympani* is convex externally; and no muscles are fixed to the bones of their ear, which are rather of a cartilaginous consistence: Any tremulous motions impressed on the air are communicated in these creatures merely by the spring and elasticity of these bones; so, probably, the membrane is not so stretched as in the human

human ear by muscles. The semicircular canals are very distinct, and easily prepared.

### The ANATOMY of a CARNIVOROUS BIRD.

WE come next to the birds of prey, and for an example shall take a stunnel or small hawk. The principal difference to be observed in them, is in their chylopoietic viscera, which may be accounted for from their different way of life.

Immediately under their clavicles, you will observe the œsophagus expanded into their *ingluvies*, which is proportionally less than in the granivorous kind, since their food does not swell so much by maceration; and for the same reason, there is a less quantity of a menstruum to be found here.

They have also a *ventriculus succenturiatus*, plentifully stored with glands, situated immediately above their stomach, which we see here is thin and musculo-membranous, otherwise than in the granivorous kind: and this difference, which is almost the only one we shall find betwixt the two different species of fowls, is easily accounted for from the nature of their food, which requires less attrition, being easier of digestion than that of the other kind; nevertheless, it seems requisite it should be stronger than the human, to compensate the want of abdominal muscles, which are here very thin.

The same mechanism obtains in this creature's *duodenum*, that we have hitherto observed. As being a carnivorous animal, its guts are proportionally shorter than those of the granivorous kind; for the reason first given, viz. its food being more liable to corrupt, therefore not proper to be long detained in the body; and for that reason it has no *intestina cæca*, of which the other species of fowls have a pair. The difference in their

their wings, backs, and claws, are obvious ; and have been already in some measure observed.

## The ANATOMY of AQUEOUS ANIMALS.

### I. AMPHIBIOUS.

AQUEOUS animals are generally divided into such as have lungs, and such as want them. The first species differ so inconsiderably from an ox or any other quadruped, that a few observations may be sufficient to give an idea of their internal structure ; for this purpose, we shall first examine that species of them which most resembles man in the internal structure, the tortoise.

TORTOISE. The covering of this animal is composed of a shell so remarkably hard and firm in its texture, that a loaded waggon may go over it, without hurting the shell or the animal within it. In the young animal, this shell grows harder in proportion as its contents expand ; and this creature never changes its shell as some others do : hence it was necessary for it to be made up of different pieces ; and these are more or less distinct in different animals. Their feet are small and weak ; and they are exceedingly slow in motion.

It has neither tongue nor teeth ; to make up for which, their lips are so hard as to be able to break almost the hardest bodies.

The alimentary canal very much resembles that of the former class.

The principal difference is in the circulation of the blood. The heart has two distinct auricles, without any communication ; and under these, there is the appearance of two ventricles similar in shape to those of the former class : but they may be considered as one cavity ; for, the ventricle sends out not only the pulmonary artery, but likewise the aorta ; for there is a pa-

passage in the septum, by which the ventricles communicate freely, and the blood passes from the left into the right one. From the aorta the blood returns into the right auricle, while that from the pulmonary artery returns to the left auricle, from which it is sent to the left ventricle, &c. so that only a part of the blood is sent to the lungs, the rest going immediately into the aorta; hence the animal is not under the necessity of breathing so often as otherwise it would be.

*Blood-vessels.* From the base of the right ventricle goes out the pulmonary artery and aorta. The pulmonary artery is spent upon the lungs. The aortæ may be said to be three in number: for the aorta sinistra ascends through the pericardium in company with the pulmonary artery; and afterwards turns down, and sends off a considerable branch, which splits into two; one of which joins the right aorta, while the other is distributed upon the liver, stomach, intestines, &c. What remains of this aorta runs to the kidneys or posterior extremities of that side. An aorta descendens, &c. after piercing the pericardium, runs down and communicates with the branch already mentioned, is distributed upon the right kidney and inferior extremity, and also upon the bladder and parts of generation. An aorta ascendens, after getting out of the pericardium, supplies the fore-legs, neck, and head. The blood in the superior part of the body returns to the right auricle by two jugular veins, which unite after perforating the pericardium. From the inferior part, it returns to the same auricle by two large veins; one on the right side receives the blood in the right lobe of the liver; the other on the left side receives the blood in the left lobe, and also a trunk which corresponds with the inferior vena cava in other animals. The pulmonary vessels run in the left auricle in the common way.

*Absorbents.* The absorbent system in the turtle, like that in the former class, consists of lacteals and lymphatics,

phatics, with their common trunks the thoracic ducts ; but differs from it in having no obvious lymphatic glands on any part of its body, nor plexus formed at the termination in the red veins.

The *lacteals* accompany the blood-vessels upon the mesentery, and form frequent net-works across these vessels : near the root of the mesentery a plexus is formed, which communicates with the lymphatics coming from the kidneys and parts near the anus. At the root of the mesentery on the left side of the spine, the lymphatics of the spleen join the lacteals ; and immediately above this a plexus is formed, which lies upon the right aorta. From this plexus a large branch arises, which passes behind the right aorta to the left side, and gets before the left aorta, where it assists in forming a very large receptaculum, which lies upon that artery.

From this receptaculum arise the thoracic ducts. From its right side goes one trunk, which is joined by that large branch that came from the plexus to the left side of the right aorta, and then passes over the spine. This trunk is the thoracic duct of the right side ; for having got to the right side of the spine, it runs upwards, on the inside of the right aorta, towards the right subclavian vein ; and when it has advanced a little above the lungs, it divides into branches, which near the same place are joined by a large branch, that comes up on the outside of the aorta. From this part upwards, those vessels divide and subdivide, and are afterwards joined by the lymphatics of the neck, which likewise form branches before they join those from below. So that between the thoracic duct and the lymphatics of the same side of the neck, a very intricate net-work is formed ; from which a branch goes into the angle between the jugular vein and the lower part or trunk of the subclavian. This branch lies therefore on the inside of the jugular vein, whilst another gets to the outside of it, and seems to terminate in it, a little

above the angle, between that vein and the subclavian.

Into the above-mentioned receptaculum the lymphatics of the stomach and duodenum likewise enter. Those of the duodenum run by the side of the pancreas, and probably receive its lymphatics and a part of those of the liver. The lymphatics of the stomach and duodenum have very numerous anastomoses, and form a beautiful net-work on the artery, which they accompany. From this receptaculum likewise (besides the trunk already mentioned, which goes to the right side) arise two other trunks pretty equal in size; one of which runs upon the left side, and the other upon the right side of the left aorta, till they come within two or three inches of the left subclavian vein; where they join behind the aorta, and form a number of branches which are afterwards joined by the lymphatics of the left side of the neck; so that here a plexus is formed as upon the right side. From this plexus a branch issues, which opens into the angle between the jugular and subclavian vein.

**SERPENT AND CROCODILE.** The circulation in these is similar to that of the turtle; but we find only one ventricle. The blood goes from the right auricle to the ventricle which sends out the pulmonary artery and aorta; the blood from the pulmonary artery returns to the left auricle, that from the aorta going to the right auricle, and both the auricles opening into the ventricle.

**FROG AND LIZARD.** These differ from the former animals, in having only one auricle and a ventricle: and besides, the ventricle sends out a single artery, which afterwards splits into two parts; one to supply the lungs, the other runs to all the rest of the body: from the lungs and from the other parts, the blood returns into the auricle.

## II. FISHES.

## II. FISHES.

OF these we may first observe, that they have a very strong thick *cuticle*, covered with a great number of scales, laid one on another like the tiles of houses. This among other arguments is supposed to prove the human epidermis to be of a squamous structure: but the scales resemble the hairs, wool, feathers, &c. of the creatures that live in air; and below these we observe their proper *cuticula* and *cutis*.

The generality of fishes, particularly those shaped like the cod, haddock, &c. have a line running on each side. These lines open externally by a number of ducts, which throw out a mucous or slimy substance that keeps them soft and clammy, and seems to serve the same purpose with the mucous glands or ducts which are placed within many of our internal organs.

In the next place, these creatures have neither anterior nor posterior extremities, as quadrupeds and fowls; for their progression is performed in a different way from either of those species of animals: for this purpose they are provided with machines, properly consisting of a great number of elastic beams, connected to one another by firm membranes, and with a tail of the same texture; their spine is very moveable towards the posterior part, and the strongest muscles of their bodies are inserted there. Their tails are so framed as to contract to a narrow space when drawn together to either side, and to expand again when drawn to a straight line with their bodies; so, by the assistance of this broad tail, and the fins on their sides, they make their progression much in the same way as a boat with oars on its sides and rudder at its stern. The perpendicular fins situated on the superior part of their body keep them in *æquilibrio*, hindering the belly from turning uppermost: which it would readily do, because of the air-bag in the abdomen rendering their belly specifical-

ly lighter than their back ; but by the resistance these fins meet with when inclined to either side, they are kept with their backs always uppermost.

The best account of this matter, we have in the treatise before-mentioned, viz. *Borelli de Motum Animalium, cap. 23.*

It may be next observed, that these creatures have nothing that can be called a *neck*, seeing they seek their food in an horizontal way, and can move their bodies either upwards or downwards, as they have occasion, by the contraction or dilatation of the air-bag ; a long neck, as it would hinder their progression, would be very disadvantageous in the element they live in.

The *abdomen* is covered on the inferior part with a black-coloured thin membrane resembling our peritoneum. It is divided from the thorax by a thin membranous partition, which has no muscular appearance ; so that we have now seen two different sorts of animals that have no muscular diaphragm.

These creatures are not provided with *teeth* proper for breaking their aliment into small morsels, as the food they use is generally small fishes, or other animals that need no trituration in the mouth, but spontaneously and gradually dissolve into a liquid chyle. Their teeth serve to grasp their prey, and hinder the creatures they have once catched from escaping again. For the same purpose, the internal cartilaginous basis of the bronchi, and the two round bodies situated in the posterior part of the jaws, have a great number of tenter-hooks fixed into them, in such a manner as that any thing can easily get down, but is hindered from getting back. The water that is necessarily taken in along with their food in too great quantities to be received into their jaws in deglutition, passes betwixt the interstices of the bronchi and the flap that covers them. The compression of the water on the bronchi is of considerable use to the creature, as we shall explain by and by.

The *œsophagus* in these creatures is very short, and scarcely distinguished from their stomach, seeing their food lies almost equally in both. The stomach is of an oblong figure. There are commonly found small fishes in the stomach of large ones still retaining their natural form; but when touched, they melt down into a jelly. From this, and the great quantity of liquors poured into their stomachs, we may conclude, that digestion is solely brought about in them by the dissolving power of a menstruum, and that no trituration happens here.

The *guts* in these animals are very short, making only three turns; the last of which ends in the common cloaca for the faeces, urine, and semen, situated about the middle of the inferior part of their bodies.

What I call *pancreas*, some give the name of *intestinula cæca* to: it consists of a very great number of small threads, like so many little worms, which all terminate at last in two larger canals, that open into the first gut, and pour into it a viscid liquor much about the place where the biliary ducts enter. That kind of pancreas formed of *intestinula cæca* is peculiar to a certain kind of fishes; for the cartilaginous, broad, and flat kind, as the skate, sole, flounder, &c. have a pancreas resembling that of the former class of animals. Their intestines are connected to the back-bone by a membrane analogous to a mesentery.

Their *liver* is very large, of a whitish colour, and lies almost in the left-side wholly, and contains a great deal of fat or oil.

The *gall bladder* is situated a considerable way from their liver; and sends out a canal, the cystic duct, which joins with the hepatic duct just at the entry into the gut. Some fibres are stretched from the liver to the gall-bladder; but none that I know of have hitherto discovered any cavity in these cords: so in this animal it should seem impossible that the bile can be carried into the gall-bladder in the ordinary way; and con-

consequently must either be secreted on the sides of that sac, or regurgitate into it from the canalis chole-dochus \*.

The *spleen* is placed near the back-bone, and at a place where it is subjected to an alternate pressure from the constriction and dilatation of the air-bag, which is situated in the neighbourhood. Since, in all the different animals we have dissected, we find the spleen attached to somewhat that may give it a conquassation; as in the human subject and quadrupeds, it is contiguous to the diaphragm; in fowls, it is placed betwixt the back bone, the liver, and stomach; in fishes, it lies on the *saccus aërius*: and since we find it so well served with blood-vessels, and all its blood returning into the liver; we must not conclude the spleen to be an *inutile pondus*, only to serve as a balance to the animal *pro æquilibrio*, but particularly designed for preparing the blood to the liver.

The only organs of *generation* in this animal are two bags situated in the abdomen uniting near the podex. These in the male are filled with a whitish firm substance called the *milt*; and in the female with an infinite number of little ova clustered together, of a reddish yellow colour, called the *roe*. Both these at spawning-time we find very much distended; whereas at another time the male organs can scarce be distinguished from the female; nor is there any proper instrument in the male for throwing the seed into the organs of the female, as in other creatures. I shall not take upon me to determine the way whereby the female sperm is impregnated; but we find that the spawn of frogs consists in the small specks wrapped up in a whitish glutinous liquor; these specks are the rudiments of the young frogs, which are nourished in that liquor

F f 2

till

\* Here we may make the same remark as upon the biliary ducts of fowls, viz. that hepato-cystic ducts exist in the one as well as the other. This, for example, is very obvious in the salmon, where large and distinct ducts run from the biliary ducts of the liver, and open into the gall-bladder.

till they are able to go in search of their food\*. In the same way, the ova of fishes are thrown out and deposited in the sand, the male being for the most part ready to impregnate them, and they are incubated by the heat of the sun. It is curious enough to remark with what care they seek for a proper place to deposite their ova, by swimming to the shallow, where they can better enjoy the sun's rays, and shun the large jaws of other fishes. The river-fishes, again, spawn in some creek free from the hazard of the impetuous stream. But whether this mixture be brought about in fishes by a simple application of the genitals to each other, or if both of them throw out their liquors at the same time in one place, and thus bring about the desired mixture, it is not easy to determine; the latter, I think, seems most probable. These creatures are so shy, that we cannot easily get to observe their way of copulation, and are consequently but little acquainted with their natural history. Frogs, it is very evident, do not copulate; at least no farther than to allow both sexes an opportunity of throwing their sperm. Early in the spring the male is found for several days in close contact upon the back of the female, with his fore-legs round her body in such a manner that makes it very difficult to separate them, but there is no communication. At this time the female lays her spawn in some place that is most secure, while the male emits his sperm upon the female spawn.

After raising up the black peritoneum in fishes, there comes in view an oblong white membranous bag, in which there is nothing contained but a quantity of elastic air. This is the *swimming-bladder*: it lies close

to

\* Spallanzani has found, that the eggs of frogs, toads, and water mewts, are not fecundated in the body of the female; that the male emits his semen upon the spawn while it is flowing from the female; and that the foetus pre-exists in the body of the female: but whether impregnation takes place in the same manner in fishes, he has not yet been able to determine, though he seems to think it probable. See *Dissertations relative to the Natural History of Animals and Vegetables*, Vol. II.

to the back-bone; and has a pretty strong muscular coat, whereby it can contract itself. By contracting this bag, and condensing the air within it, they can make their bodies specifically heavier than water, and so readily fall to the bottom; whereas the muscular fibres ceasing to act, the air is again dilated, and they become specifically lighter than water, and so swim above. According to the different degrees of contraction and dilatation of this bladder, they can keep higher or lower in the water at pleasure. Hence flounders, soles, raia or skate, and such other fishes as want this sac, are found always groveling at the bottom of the water: it is owing to this that dead fishes (unless this membrane has been previously broke) are found swimming a-top, the muscular fibres then ceasing to act, and that with their bellies uppermost; for the back-bone cannot yield, and the distended sac is protruded into the abdomen, and the back is consequently heaviest at its upper part, according to their posture. There is here placed a glandular substance, containing a good quantity of red blood; and it is very probable that the air contained in the swimming-bladder, is derived from this substance. From the anterior part of the bag go out two *processes* or *appendices*, which, according to the gentlemen of the French academy, terminate in their fauces: In a variety of other fishes we find communications with some parts of the alimentary canal, particularly the oesophagus and stomach. The salmon has an opening from the fore end of the air-bag into the oesophagus, which is surrounded by a kind of muscular fibres. The herring has a funnel-like passage leading from the bottom of the stomach into the air-bag; but it is not determined whether the air enters the air-bag by this opening, or comes out by it: the latter, however, seems to be the more probable opinion, as the glandular body is found in all fishes, whereas there are several without this passage of communication.

But in some fishes, as the cod and haddock, I never could find out this communication, either by tracing them, pouring in mercury or water, &c. I put, it is true, a probe through them; but then with the same strength I could have put it through the sides of the processes.

At the superior part of this bag there are other red-coloured bodies of a glandular nature, which are connected with the kidneys. From them the *ureters* go down to their insertion in the *vesica urinaria*, which lies in the lower part of the abdomen; and the urethra is there produced, which terminates in the podex.

These last-mentioned parts have not hitherto been observed in some species of fishes; whence authors too hastily denied them in all. These creatures have a membranous diaphragm, which forms a sac in which the heart is contained. It is very tense, and almost perpendicular to the vertebræ.

The heart is of a triangular form, with its base downwards, and its apex uppermost; which situation it has because of the *branchiæ*. It has but one *auricle* and one *ventricle*, because they want lungs, and one great artery. The size of the auricle and that of the ventricle are much the same; the artery sends out numberless branches to the *branchiæ* or gills. And what is rather curious, this artery, instead of supporting all parts as in the frog, is distributed entirely upon the gills; every branch terminating there, and becoming so extremely small as at last to escape the naked eye.

The *branchiæ* lie in two large slits at each side of their heads, and seem to be all they have that bears any analogy to lungs. Their form is semicircular; they have a vast number of red fibrillæ standing out on each side of them like a fringe, and very much resemble the vane of a feather. These *branchiæ* are perpetually subjected to an alternate motion and pressure from the water; and we may here remark, that we have not found

found any red blood but in places subjected to this alternate pressure. This observation will help us in explaining the action of the lungs upon the blood. Over these gills there is a large flap, allowing a communication externally; by which the water they are obliged to take into their mouths with their food finds an exit without passing into their stomach: it is owing to these flaps coming so far down that the heart is said commonly to be situated in their heads. The blood is collected again from the gills by a vast number of small veins, somewhat in the same manner as in our pulmonary vein; but instead of going back to the heart a second time, they immediately unite, and form an aorta descendens without the intervention of an auricle and ventricle. Hence a young anatomist may be puzzled to find out the power by which the blood is propelled from the gills to the different parts of the body; but the difficulty will be considerably lessened when we consider the manner in which the blood is carried through the liver from the intestines in man and quadrupeds. The aorta in fishes sends off branches which supply all the parts of the body excepting the gills. From the extremity of those branches the blood returns to the heart somewhat in the same manner as in the former class of animals; only there are two inferior venæ cavae, whereas the former has but one.

*Absorbent System in Fishes.* We shall take the Haddock as a general example: for the other fishes, particularly those of the same shape, will be found in general to agree with it.

On the middle of the belly of a haddock, immediately below the outer skin, a lymphatic vessel runs upwards from the anus, and receives branches from the parietes of the belly, and from the fin below the anus: near the head this lymphatic passes between the two pectoral fins; and having got above them, it receives their lymphatics. It then goes under the symphysis of the two bones which form the thorax, where it opens

into a net-work of very large lymphatics, which lie close to the pericardium, and almost entirely surrounds the heart. This net-work, besides that part of it behind the heart, has a large lymphatic on each side, which receives lymphatics from the kidney, runs upon the bone of the thorax backwards, and when it has got as far as the middle of that bone, it sends off a large branch from its inside to join the thoracic duct. After detaching this branch, it is joined by the lymphatics of the thoracic fins, and soon after by a lymphatic which runs upon the side of the fish. It is formed of branches, which give it a beautiful penniform appearance.

Besides these branches, there is another set deeper which accompanies the ribs. After the large lymphatic has been joined by the above-mentioned vessels, it receives lymphatics from the gills, orbit, nose, and mouth. A little below the orbit, another net-work appears, consisting in part of the vessels above-described, and of the thoracic duct. This net-work is very complete, some of its vessels lie on each side of the muscles of the gills; and from its internal part, a trunk is sent out which terminates in the jugular vein.

The lacteals run on each side of the mesenteric arteries, anastomosing frequently across those vessels. The receptaculum into which they enter is very large, in proportion to them; and consists at its lower part of two branches, of which one lies between the duodenum and stomach, and runs a little way upon the pancreas, receiving the lymphatics of the liver, pancreas, those of the lower part of the stomach, and the lacteals from the greatest part of the small intestines. The other branch of the receptaculum, receives the lymphatics from the rest of the alimentary canal. The receptaculum formed by these two branches lies on the right side of the upper part of the stomach, and is joined by some lymphatics in that part, and also by some from the fund and gall-bladder, which in this fish adheres

heres to the receptaculum. This thoracic duct takes its rise from the receptaculum, and lies on the right side of the œsophagus, receiving lymphatics from that part ; and running up about half an inch, it divides into two ducts, one of which passes over the œsophagus to the left side, and the other goes straight upon the right side, passes by the upper part of the kidney, from which it receives some small branches, and soon afterwards is joined by a branch from the large lymphatic that lies above the bone of the thorax, as formerly mentioned : near this part, it likewise sends off a branch to join the duct of the opposite side; and then, a little higher, is joined by those large lymphatics from the upper part of the gills, and from the fauces.

The thoracic duct, after being joined by these vessels, communicates with the net-work near the orbit, where its lymph is mixed with that of the lymphatics from the posterior part of the gills, and from the superior fins, belly, &c. and then from this net-work, a vessel goes into the jugular vein just below the orbit. This last vessel, which may be called the termination of the whole system, is very small in proportion to the net-work from which it rises ; and indeed the lymphatics of the part are so large, as to exceed by far the size of the sanguiferous vessels.

The thoracic duct from the left side, having passed under the œsophagus from the right, runs on the inside of the vena cava of the left side, receives a branch from its fellow of the opposite side, and joins the large lymphatics which lie on the left-side of the pericardium, and a part of those which lie behind the heart ; and afterwards makes, together with the lymphatics from the gills, upper fins, and side of the fish, a net-work, from which a vessel passes into the jugular vein of this side. In a word, the lymphatics of the left-side agree exactly with those of the right-side above described. Another part of the system is deeper seated, lying between the roots of the spinal processes of the

back-bone. This part consists of a large trunk that begins from the lower part of the fish, and as it ascends receives branches from the dorsal fins and adjacent parts of the body. It goes up near the head, and sends a branch to each thoracic duct near its origin.

The *brain* in fishes is formed pretty much in the same way as that of fowls ; only we may observe, that the posterior lobes bear a greater proportion to the anterior.

Their organ of *smelling* is large ; and they have a power of contracting and dilating the entry into their nose as they have occasion. It seems to be mostly by their acute smell that they discover their food : for their tongue seems not to have been designed for a very nice sensation, being of a pretty firm cartilaginous substance ; and common experience evinces, that their sight is not of so much use to them as their smell in searching for their nourishment. If you throw a fresh worm into the water, a fish shall distinguish it at a considerable distance ; and that this is not done by the eye, is plain from observing, that after the same worm has been a considerable time in the water and lost its smell, no fishes will come near it : but if you take out the bait, and make several little incisions into it, so as to let out more of the odoriferous effluvia, it shall have the same effect as formerly. Now it is certain, had the creatures discovered this bait with their eyes, they would have come equally to it in both cases. In consequence of their smell being the principal means they have of discovering their food, we may frequently observe their allowing themselves to be carried down with the stream, that they may ascend again leisurely against the current of the water ; thus the odoriferous particles swimming in that medium, being applied more forcibly to their smelling organs, produce a stronger sensation.

The *optic nerves* in these animals are not confounded with one another in their middle progress betwixt their

their origin and the orbit, but the one passes over the other without any communication; so that the nerve that comes from the left side of the brain goes distinctly to the right eye, and *vice versa*.

Indeed it would seem not to be necessary for the optic nerves of fishes to have the same kind of connection with each other as those of man have: for their eyes are not placed in the fore-part, but in the sides of their head; and of consequence, they cannot so conveniently look at any object with both eyes at the same time.

The *lens crystallina* is here a complete sphere, and more dense than in terrestrial animals, that the rays of light coming from water might be sufficiently refracted.

As fishes are continually exposed to injuries in the uncertain element they live in, and as they are in perpetual danger of becoming a prey to the larger ones, it was necessary that their eyes should never be shut; and as the cornea is sufficiently washed by the element they live in, they are not provided with palpebrae: but then, as in the current itself the eye must be exposed to several injuries, there was a necessity it should be sufficiently defended; which in effect it is by a firm pellucid membrane that seems to be a continuation of the cuticula, being stretched over here. The epidermis is very proper for this purpose, as being insensible, and destitute of vessels, and consequently not liable to obstructions, or, by that means, of becoming opaque. In the eye of the skate tribe, there is a digitized curtain which hangs over the pupil, and may shut out the light when the animal rests, and it is similar to the tunica adnata of other animals.

*Ear of Fishes.* Although it was formerly much doubted whether fishes possessed a sense of hearing, yet there can be little doubt of it now; since it is found that they have a complete organ of hearing as well as other animals, and likewise as the water in which they live is proved to be a good medium. Fishes, particularly

larly those of the skate kind, have a bag at some distance behind the eyes, which contains a fluid and a soft cretaceous substance, and supplies the place of vestibule and cochlea. There is a nerve distributed upon it, similar to the portio mollis in man. They have semicircular canals, which are filled with a fluid, and communicate with the bag : they have likewise, as the present professor of anatomy here has lately discovered, a meatus externus, which leads to the internal ear. The cod fish, and others of the same shape, have an organ of hearing somewhat similar to the former ; but instead of a soft substance contained in the bag, there is a hard crustaceous stone. In this kind of fish no meatus externus has been yet observed.

### The ANATOMY of INSECTS.

**A**S insects and worms are so exceedingly numerous, it would be endless to examine all the different kinds, nor would it serve any useful purpose to the anatomist. We shall therefore be content with making a few general observations, and these chiefly on the structure of their body ; leaving the variety of their colour, shape, &c. to the naturalist. Insects differ from the former classes, by their bodies being covered with a hard crust or scale, by their having feelers or antennæ arising from their head, and many of them breathing the air through lateral pores. As to the shape of their bodies, though it somewhat differs from that of birds, being in general not so sharp before to cut and make way through the air, yet it is well adapted to their manner of life. The base of their bodies is not formed of bone, as in many other animals, but the hard external covering serves them for skin and bone at the same time. Their feelers, beside the use of cleaning their eyes, are a guard to them in their walk or flight. Their legs and wings are well fitted for their intended service ; but the latter vary so much in different

rent insects, that from them naturalists have given names to the several orders of the class. As, first, the

*Coleoptera*, or beetle tribe, which have a crustaceous elytra or shell, that shuts together, and forms a longitudinal suture down their back.

*Hæmiptera*—as in cimex, cockroach, bug, &c. which have the upper wings half crustaceous, and half membranaceous; not divided by a longitudinal suture, but incumbent on each other.

*Lepidoptera*—as the butterfly, have four wings, covered with fine scales in the form of powder.

*Neuroptera*—as the dragon-fly, spring-fly, &c. have four membranaceous transparent naked wings, generally reticulated.

*Hymenoptera*—as wasps, bees, &c. have four membranaceous wings, and a tail furnished with a sting.

*Diptera*—as the common house-fly, have only two wings.

*Aptera*—as the lobster, crab, scorpion, spider, &c. have no wings.

The structure of the Eye in many insects is a most curious piece of mechanism. The outer part is remarkably hard, to guard against injuries; and has commonly a reticular appearance, or the whole may be looked upon as an assemblage of smaller eyes; but whether they see objects multiplied before them, has not yet been determined.

Linnaeus, and several others following him, deny the existence of a Brain in these creatures. But it is certain, that at least a number of the larger kinds, as the lobster, crab, &c. have a soft substance similar to the brain, from which the optic and other nerves take their rise; besides, when this substance is irritated, the animal is thrown into convulsions: hence we would conclude, that insects have a brain as well as the former classes, although this is smaller in proportion to their bodies.

Their

Their Ear has been lately discovered to be placed at the root of their antennæ or feelers, and can be distinctly seen in some of the larger kinds, as the lobster.

They have a Stomach, and other organs of digestion ; and it is curious, that in some, as the lobster, the teeth are found in the stomach.

They have a Heart and blood-vessels, and circulation is carried on in them somewhat as in the former class ; but the blood is without red globules ; or, as naturalists speak, is colourless. In the lobster, and others of the larger kind, when a piece of the shell is broken, the pulsation of the heart is seen distinctly, and that sometimes for several hours after it has been laid bare.

*Lungs.* The existence of these by some has been denied. But late experiments and observations show, that no species want them, or at least something similar to them ; and in many insects, they are larger in proportion than in other animals : in most of them, they lie on or near the surface of their body ; and send out lateral pores or tracheæ, by which, if the animal is besmeared with oil, it is instantly suffocated.

*Generation.* The same difference in sex exists in insects as in other animals, and they even appear more disposed to increase their species ; many of them, when become perfect, seeming to be created for no other purpose but to propagate their like. Thus the silk-worm, when it arrives at its perfect or moth-state, is incapable of eating, and can hardly fly ; it endeavours only to propagate its species : after which the male immediately dies, and so does the female as soon as she has deposited her eggs.

Besides those of the male and female, a third sex exists in some insects, which we call *neuter*. As these have not the distinguishing parts of either sex, they may be considered as eunuchs or infertile. We know of no instance of this kind in any other class of animals ;

mals; and it is only found among those insects which form themselves into societies, as bees, wasps, and ants: and here these eunuchs are real slaves, as on them lies the whole business of the economy. No hermaphrodites have as yet been discovered among insects.

Many have imagined that the generality of insects were merely the production of putrefaction, because they have been observed to arise from putrefied substances: but a contrary opinion is now more generally adopted; and it is pretty certain, that if putrid bodies be shut up in a close vessel, no insects are ever generated unless their ova have been originally deposited there. They are oviparous animals, and lay their eggs in places most convenient for the nourishment of their young; some in water, others in flesh; some in fruit and leaves; while others make nests in the earth or in wood, and sometimes even in the hardest stone. The eggs of all insects first become (*larva*) caterpillar or maggot; from which they are changed into (*pupa*) chrysalis or aureliae, so named from their being inclosed in a case; and these dying, or seeming to die, the (*imago*) fly, or butterfly or perfect state succeeds; and during each of these changes their appearance differs wonderfully.

### Of WORMS.

WITH respect to this class of animals, they have characters corresponding with those of the former tribe, but are distinguished from them in having no antennæ, and in being furnished with tentaculo.

Many of them, particularly those without shells, are remarkably tenaceous of life, sometimes capable of being new formed from a part which may have been separated. By much the greater number of them are destitute of head, ears, nose, eyes, and feet.

Some of those in the first order, as the common

round worms, have a vascular and nervous system, with the parts of generation, which can be distinctly seen. Some, as the cuttle fish, form a kind of connection between fishes and worms, in possessing gills but wanting fins, &c. while others, as those of the lowest order, or zoophyta, join the properties of the animal and vegetable kingdom together.

The class is divided by Linnæus, &c. into the following orders, viz.

*Intestina*—as the earth worm, leech, &c. which are the most simple animals, being perfectly naked, and without limbs of any kind.

*Mollusca*—as the naked snail, sea star, cuttle fish; which are likewise simple animals without any shell, but they are brachiated or furnished with a kind of limbs.

*Testacea*—as the snail, oyster, &c. which have the same characters as the former order, but are covered with a shell, and include the greater part of what we commonly call shell-fish.

*Lithophyta*—as corals, madrepors, &c. which are compound animals fixed upon a calcareous base, constructed by the creatures themselves.

*Zoophyta*—as the sponge, polypus, &c. These are likewise compound animals, furnished with a kind of flowers, and having a vegetating root and stem.

Some of these creatures inhabit the earth, others live on the rest of the animal or on the vegetable kingdom, and many are found in the hardest stones; while an innumerable tribe of them live in the waters. In general, they are said to be of the hermaphrodite and oviparous kind; while the lowest class, as the polypi, in a great measure resemble the vegetable kingdom in their manner of growth: but for the propagation of these animals, as well as of the others of this class, we refer the reader to the various books which have lately been written on natural history.

# INDEX

## TO VOLUME THIRD.

### A.

**A**BDOMEN. Many lymphatic glands contained in its cavity, 229.  
Absorbent system, 206. History of its discovery, *ib.* Of the system in general, 208. Particular description of it, 212  
Absorbent vessels of the trunk, 218. See lymphatic vessels.  
Absorption by the lymphatic vessels treated of, 264  
Æther, universally diffused, cannot be applied to the animal economy, 287  
Air, how it gets admission during incubation into an egg, 419, n  
Allantois has no existence in human subjects, 25. Its situation and use in brutes, 25. The arguments for and against its existence in the human species considered, 53, 395. Description of it in quadrupeds, 395  
Amnion, the finest and strongest of all the uterine membranes, 25  
Amnios, a fine transparent membrane enveloping the foetus, 17. Has no conspicuous blood-vessels, 51. Extended under the placenta, *ib.* A particular membrane of this kind for each foetus, *ib.*  
Amphibious animals supposed to have no other absorbent system than the red veins, 261. Anatomy of them, 436  
Amputations, several symptoms attending them explained, 329  
Analarea, the water collected in that disease sometimes absorbed and evacuated by stool or urine, 255  
Anastomosis between the vessels of the mother and those of the placenta, seems probable from hemorrhages following the extraction of it, 49  
Angina occasions a pain in the teeth and ear, 309  
Animal food, those creatures which feed on it have less capacious, and stronger bladders than others, 357  
Animal kingdom so nearly connected with the vegetable, that their limits can scarcely be determined, 344  
Antrum Willefii wanting in the stomach of a dog, 349  
Aorta receives the blood from the left ventricle of the heart, 93. Distrib-

butes it to all parts of the body, 110. Its general division, 112. Examination of its capital or original branches, 116  
Aqueous animals, their anatomy, 436  
Arms, each of them has two sets of lymphatic vessels, 234  
Arteria angularis, a branch of the external carotid distributed on the nose, &c. 119.  
Arteria articularis, a branch of the axillary artery distributed on the deltoid muscle, 133  
Arteria axillaris, the name of the subclavian artery, as it goes out of the thorax and passes under the axilla, 114, 133  
Arteria auditoria interna, a branch of the basilaris distributed on the organ of hearing, 129  
Arteria basilaris, the common trunk of the posterior occipital arteries, 128  
Arteria biliaria, a branch of the right gastric artery, lost in the great lobe of the liver, 143  
Arteria brachialis, a branch of the axillary artery, running down the inside of the arm, 134  
Arteria bronchialis, a branch of the superior intercostal, aorta, or arteria oesophagea, 130. Mistake concerning the communications of this with the pulmonary artery, *ib.*  
Arteria carotis externa, a branch of the great carotid trunk, distributed on the external parts of the head, 118  
Arteria carotis interna, a branch of the great carotid trunk, distributed on the internal parts of the head, and entering through the os petrosum, 121  
Arteria coeliaca, a branch of the aorta descendens distributed on the stomach, liver, and spleen, 141  
Arteria cervicalis, a branch of the subclavians artery distributed on the neck, 126  
Arteria circumflexa externa, the external branch of the crural artery running on the upper side of the thigh, 157  
Arteria circumflexa interna, another branch of the crural artery, and supplying

- plying many of the muscles of the thighs, 157
- Arteria colica superior**, a branch of the superior mesenteric artery, forming a communication with the mesenterica inferior, 146
- Arteria colica sinistra**, a branch of the inferior mesenteric, running along the last portion of the colon, 147
- Arteria cubitalis**, a branch of the brachialis, running down the inside of the cubit, 134, 136
- Arteria diaphragmatica**, a branch of the aorta descendens, or coeliac artery, running along the concave side of the diaphragm, 141
- Arteria duodenalis**, a branch of the right gastric artery running along the side of the duodenum next the pancreas, 143.
- Arteria epigastrica**, the internal branch of the iliac, anastomosing with the mammaea interna, 151
- Arteria epiploica**, a branch of the splenic artery distributed on the omentum, 144
- Arteria gastrica**, the coronary of the stomach, 142. See *arteria ventriculi coronaria*
- Arteria gastrica dextra**, a branch of the hepatic artery, passing behind the pylorus, 143
- Arteria gastrica major**, another name for the preceding
- Arteria gastrica minor**, the same with the gastrica sinistra
- Arteria gastrica sinistra**, a branch of the splenic artery, running along the great curvature of the stomach, 144
- Arteria gastrica superior**, the same with the ventriculi coronaria
- Arteria glutaea**, the same with the iliaca posterior, distributed on the glutaeus maximus and medius, 153
- Arteria gutturalis inferior**, 125. The same with the trachealis
- Arteria gutturalis superior**, a branch of the external carotid, distributed on the larynx and thyroid glands, 118
- Arteria haemorrhoidalis externa**, a branch of the pudica interna, going to the sphincter ani, 154
- Arteria haemorrhoidalis interna**, a branch of the inferior mesenteric, distributed on the rectum, 147
- Arteria haemorrhoidal media**, a branch of the pudica interna, distributed on the rectum, 155. More frequent in women than men, 155
- Arteria hepatica**, a branch of the caeliac, running on the upper and inner part of the pylorus, 142
- Arteria hypogastrica**, the same with the iliaca interna, distributed on the viscera of the pelvis, &c. 116. Much smaller in proportion in adults than in children, 151
- Arteria intestinalis**, the same with duodenalis.
- Arteria intercostalis superior**, a branch of the aorta or subclavian, distributed on the intercostal muscles, 129
- Arteria labialis**, a branch of the external carotid, distributed on the muscles of the lips, 119
- Arteria iliaca posterior**, the same with the glutaea
- Arteria iliaca minor**, sometimes a branch of the glutaea, distributed on the iliac muscle and os ilium, 153
- Arteria ileo-lumbaris**, the same with iliaca minor
- Arteria mammaea interna**, a branch of the subclavian, running down behind the cartilages of the ribs, 125
- Arteria maxillaris externa**, the same with the labialis
- Arteria maxillaris interna**, a large branch of the external carotid, sending off a great number of other branches, 119. A list of its most considerable branches, 120
- Arteria mediastina**, a branch of the subclavian distributed to the mediastinum, 125
- Arteria meningea posterior**, a branch of the basilaris going to the back part of the dura mater, &c. 129
- Arteria mesenterica inferior**, a branch of the aorta descendens, branched out mostly on the colon, 146, 147
- Arteria mesenterica superior**, a branch of the aorta descendens, subdivided into a great many smaller branches sent on the intestines, 144
- Arteria obturatrix**, a branch of the hypogastric perforating the obturator muscles, 156
- Arteria occipitalis**, a branch of the maxillaris interna going to the integuments of the os occipitis, 121
- Arteria occipitalis posterior**, a branch of the vertebral artery, entering the cranium and piercing the dura matter, 127

Arteria

- Arteria ophthalmica, a branch of the internal carotid distributed on the eye, 122
- Arteria pericardia, a branch of the sub-clavian running down on the pericardium to the diaphragm, 125
- Arteria peronaea posterior, a small branch of the poplitea, 158
- Arteria poplitea, the name of the crural artery, after passing through the hollow of the ham, 157
- Arteria profunda, the middle branch of the crural artery, running down the inside of the thigh, 157
- Arteria pudica externa, a branch of the hypogastric, distributed on the parts of generation, 154
- Arteria pudica interna, another branch of the hypogastric, 154
- Arteria pulmonalis, the great artery receiving the blood from the right ventricle of the heart, 110
- Arteria pylorica, a branch of the hepatic artery distributed on the pylorus, 142
- Arteria ranina, a branch of the external carotid sent to the muscles of the tongue and os hyoides, 119
- Arteria radialis, a branch of the brachialis, running down the outside of the arm, 139. Its pulse felt at the wrist, 16
- Arteria scapularis externa, a branch of the axillary going to the articulation of the scapula with the os humeri, 133
- Arteria scapularis interna, another branch of the same, running backward among the muscles, 133
- Arteria scapularis inferior, a branch of the axillary running along the inferior margin of the scapula, 133
- Arteria sciatica, a branch of the iliac, 153
- Arteria splenica, a branch of the celiac artery going to the spleen, 143
- Arteria subclavia, a large branch of the aorta, 124
- Arteria sublingualis, the same with ranina
- Arteria furalis, the same with the tibialis posterior, 159
- Arteria thoracica superior, a considerable branch of the subclavian, 132
- Arteria tibialis anterior, a branch of the poplitea, running between the tibia and fibula, 158
- Arteria tibialis posterior, a branch of the poplitea, running down the back part of the leg, 159
- Arteria trachealis, a branch of the sub-clavian distributed on the trachea, 125
- Arteria thymica, a branch of the sub-clavian sent to the thymus, 125
- Arteria vaginalis, a branch of the haemorrhoidalis media, &c. going to the vagina, 155
- Arteria ventriculi coronaria, a branch of the coeliac distributed on the stomach, 142
- Arteria vertebralis, a considerable branch of the carotid, 127
- Arteria uterina, a branch of the hypogastric, sent on the uterus and parts of generation, 155
- Arteriae adiposae, branches of the spermatic arteries sent to the kidneys, 148
- Arteriae articulares, branches of the poplitea sent to the knee, 157
- Arteriae cardiacae, branches of the aorta distributed on the heart, 116
- Arteriae carotides, two large branches of the aorta, 117
- Arteriae capsulares, branches of the aorta sent to the renal glands, 148
- Arteriae crurales, the name of the iliac arteries at their entering the thigh, 156
- Arteriae gastro-epiploicae sinistrae, branches of the gastric artery sent to the omentum, 144
- Arteriae iliaceae, the two inferior terminating branches of the aorta, 150
- Arteriae intercostales inferiores, branches of the descending aorta, 131
- Arteriae lumbares, branches of the descending aorta sent to the lumbar muscles, 149
- Arteriae oesophageae, branches of the aorta descendens sent to the oesophagus, 131
- Arteriae phrenicae, see arteria diaaphragmatica
- Arteriae pancreaticae, branches of the splenica sent to the pancreas, 145
- Arteriae sacrae, branches of the descending aorta, distributed to the rectum, &c. 149
- Arteriae facro-laterales, branches of the hypogastric artery sent to the nerves and membranes of the os sacrum, 153
- Arteriae spinales, branches of the vertebrals, running down the fore and back

- back parts of the medulla spinalis, 129  
**Arteriae vesicales**, branches of the haemorrhoidal media, &c. spent on the bladder, 155  
**Arteriae umbilicales**, branches of the aorta or iliac arteries of the foetus in utero returning the blood from it, 31. Particular description of their course, 51. Their branches from the entire substance of the placenta, 52  
**Arteries** become more dense and narrow by age, 79. A general consideration of them, 84. May be reckoned long extended cones, *ib.* Their diameter contracted where a branch is sent off, *ib.* Dilated in some places, *ib.* Have no coat common to them all, 85. Their cellular coat described, 85. Have no tendinous coat, *ib.* Description of their muscular and innermost coats, 86. Figure of their cavities, 87. Their elasticity and pulse, *ib.* Of their strength, 88. Why aneurisms are most frequently formed near the heart, 88. Their large trunks disposed in places of safety, *ib.* Proportion of their cavities to their solid parts, *ib.* Of the general division of the arteries, 89. Very frequently form anastomoses with one another, 90. Sometimes form rings returning into themselves *ib.* Sometimes are changed into veins, *ib.* or into vessels of the smaller kinds, 91. Sometimes end in exhaling vessels, 92. Discussion of the question, whether there are any arteries of a lesser order carrying humours thinner than the blood? 92. Of their common offices, 93. Their systole and diastole 94. Propel the blood by their systole, 95. Effects of the motion of the heart and arteries on the blood, 105. The reticular distributions and inoculations of the arteries prevent obstruction, 109. The arteries particularly considered, 110  
**Arterious nerves** supposed to produce muscular motion and nutrition, 285  
**Ascites**, the water in it sometimes absorbed and sent off by stool or urine, 255. Produced in a dog by tying the vena cava inferior, 259  
**Auditory nerve** described, 312  
**Axis arteriae coeliacae**, why the trunk of the coeliac artery is so called, 142  
 B.  
 Beings of different orders make a beautiful gradation in nature, 337  
 Bile does not pass through the gall-bladder in living animals, 254. In the stomach frequently occasions vomiting, 319  
**Birds**, of their generation, 40, 41, 55. Formerly supposed to have no lymphatics, 261  
**Anatomy** of a carnivorous bird, 435  
**Bladder** of a dog, why different in shape from that of the human species, 356. Mistake of anatomists concerning its figure in man, *ib.* More muscular in carnivorous animals than others, and why, 357  
 Blood how circulated through the foetus, 62. Cannot pass through the lungs, 63. At first passes directly into the aorta, *ib.* Then from the right auricle directly into the left, through the foramen ovale, 63. Never flows from the sinus of the left to that of the right auricle, *ib.* By what means the lungs of a foetus are kept free of an over-charge of blood, 64. Action of the blood on the arteries, 93. Constantly fills the arteries of a living person both in their systole and diastole, 94. A small quantity sent into the arteries at each pulsation of the heart, *ib.* Obstacles preventing too great velocity of the blood's motion, 97. Other causes by which these obstacles are lessened, 98. Action of the blood on the veins, 99. Precautions of nature to prevent the blood from concreting in them, 103. Calculation of the time in which an ounce of blood sent out from the heart returns to it again, 104. Effects of the heart and arteries upon it, 105. Causes by which they are enabled to produce these effects, 106. Whether the heat of the blood proceeds from its motion, 107. The quick motions of the blood tend to sanguification, and the slower to secretion, 108, 109, 110. Transfusion of blood in a dead body, no argument for it in a living one, 254  
 Blood-globules move quicker in the small vessels than by calculation they ought to do, 98. One of them only can pass the mouths of the smallest vessels at a time, 109. Are of a flat and circular figure, according to Mr Hewson, *ib.*  
 Bones are present in the primeval foetus, 57. May be formed out of membranes, 59. Increase of length

- in the long bones occasioned by the action of the arteries, 60. The flat bones originate from something of a membranous nature, 60. Are liable to change, 76. Sometimes become soft, *ib*.
- Pony juice, proofs of its being interposed between the primeval fibres, 61. Exudes from the substance of a broken bone, may be extracted by a chemical analysis, and is poured round the joint in an ankylosis, *ib*. Is also liable to be changed, 76.
- Bouffe noire, the name of a black triangular purse in the eyes of fowls, 434. Is connected with the humours of the eye, *ib*. Conjectures concerning its use, *ib*.
- Brain in the foetus large and fluid, 56. Probably has absorbent vessels tho' they cannot easily be discovered, 231. Much smaller in quadrupeds than in man, though divided in a similar manner in them, 372. Why their brain is smaller, *ib*.
- Brain and nerves similar to other glands and their excretaries, 283.
- Bronchial glands probably secrete a mucus, and not a lymph, 225.
- C.**
- Canalis arteriosus, a canal in the foetus communicating between the pulmonary artery and aorta, 31.
- Capitula Glissoni, a membranous sheath enveloping the vena portae, 143.
- Carnivorous bird, anatomy of one, 435.
- Carotid arteries, see arteriae carotides, and arteria carotis externa and interna.
- Cartilages, how changed into bones, 60.
- Carunculae myriiformes, how produced, 36.
- Cauda equina when cut, yields a visc'd liquor, 288. No argument can be drawn from thence concerning the viscosity of the nervous liquor, 289.
- Cerebrum and cerebellum consists of a cineritious or cortical and medullary part, with vessels passing from the one to the other, 268.
- Chewing the cud, see rumination.
- Children sometimes born without brains, 275.
- Chorion, one of the enveloping membranes of the foetus, 17. Very thin and transparent, *ib*. Adheres closely to the placenta, and gives a coat to the umbilical cord, 24. False chorion consists of two distinct layers, 17.
- Chorion laeve, a white opaque membrane, not vascular, lying under the false chorion, 50.
- Chyle, its properties previous to a mixture with the blood, 238. Absorbed into the lacteals by the adhering villous coat, through small openings in each of the villi, by the force of capillary attraction, 239. Urged on by the peristaltic motion of the intestines, *ib*. Passes through the mesenteric glands, *ib*. Appears more watery after passing through them, 240. Opinion of Haller and others concerning the causes of its motion, 241. Does not immediately change its nature when mixed with the blood, *ib*.
- Cicatrices have a progressive growth as well as those parts of the body which never were divided, 76.
- Circulation of blood, how carried on in the foetus, 30, 62. How carried on in the fetus of a cow, 398. See blood, foetus, and cow.
- Circulation of the nervous fluid considered, 285.
- Cock, anatomy of one, 409. Its oesophagus, *ib*. How digestion is performed, *ib*. Pebbles swallowed for this purpose, 410. Denied by Spallanzani, *ib*. n. No argument from thence that digestion is thus performed in the human stomach, 411. Duodenum mostly in the right side, 411. Why the food does not regurgitate, *ib*. Small intestines, spleen, and pancreas, described, 412. Heart wants the valvulae tricuspides, 413. Peculiarities in the structure of the lungs, to answer the purposes of flying, 413. Epiglottis wanting. Its place probably supplied by the muscular sides of the rima glottidis, 413. The voice owing to the coarctation of the trachea, 413. Has no muscular diaphragm, 414. Lymphatic system and course of the lacteals, 414, 415. Kidneys and organs of generation, 416. Why the cock is falacious, 416. Has two penes, the existence of which has often been denied by anatomists, 417. Nutrition of the foetus, 418. Description of the parts about the neck and head, 431. Organ of smelling, 432. How the organ of smelling is supplied in birds that grope for their food, 433.
- Description

- Description of the eyes of a cock, 433. Ear described, 434  
 Cod-fishes have an hard cretaceous stone in their heads, 452  
 Collateral arteries, a name for the three communicating branches of the brachial artery, 136  
 Colostra, a term for the first milk which purges the infant, 71  
 Comparative anatomy. Its history, 334. Its uses, 342. Anatomists frequently borrow the description of the parts of the human body from it, 334 *et seq.*  
 Conception considered at large, 33—75  
 Conglobate glands, a part of the absorbent system, 208. How placed in the lymphatic system, 211. Particular description of them, 211. Are not essentially necessary to the lymphatic system, 212  
 Corpora olivaria, the same with the ganglions of the nerves, 272  
 Corpus luteum, a small body of a yellow colour, appearing in the ovaria during pregnancy, 30. Double in case of twins, *ib.* By injections it appears composed mostly of vessels, *ib.* Is produced from one of the vesicles of the ovaria burst in a prolific copulation, 38  
 Cow, anatomy of one, 393. Form of the uterus, *ib.* Some things peculiar to the foetus, *ib.* Chorion and allantois described, 394, 395. The allantois is incapable of corruption, 395. Arguments for and against its existence in women, *ib.* Amnios described, 396. Does not enter the cornua uteri, *ib.* Foetus has two venae umbilicales, 397. Hippomanes described, *ib.* Peculiarities in the internal structure of the foetus, 397. How the circulation is performed in the foetus, 398. Dispute concerning the use of the foramen ovale and canalis arteriosus, *ib.* Kidneys, 400. The creature considered as a ruminant animal, 400. How the want of dentes incisores is supplied, *ib.* Progress of the food, and changes produced on it in the different stomachs, 401, 402. Why ruminant animals require less food than others, 403. Intestines described, 403. Duodenum, *ib.* Why cow-dung is inferior as a manure to that of horses, 404. Spleen, liver, bladder, and organs of generation described, *ib.* Situation of the heart and aorta, 405  
 Crocodile, circulation of the blood in it, 439  
 Crural vein, a branch of the vena poplitea described, 197  
 Cuticula and cutis of quadrupeds more elastic than in the human species, 346
- D.
- Death naturally follows from the progress of life and growth in the human body, 81. Rarely happens from mere old age, 82. This kind of death sometimes observed in brutes, *ib.* Manner in which death comes on, and when it is perfect, 82, 83  
 Decrease of the body cannot in any case begin from the first conception, 76. Is said to begin when the body comes to its full growth, *ib.* Cause of the decrease of the solid parts, 77. How the decrease is prevented from being too rapid, 77. Decrease begins to take place even in youth, 79  
 Delivery of women with child, by what means accomplished, 66, 67  
 Democritus, his progress in anatomy, 334  
 Derivation, a power supposed to bring the blood into the lower extremities of the foetus, 59  
 Diaphragm contains some lymphatic gland, 229. More loose in a dog than in the human species, and why, 354  
 Dog, anatomy of one, 347. Does not sweat, *ib.* But perspires insensibly, *ib.* n. Rabies canina peculiar to animals of the dog kind, *ib.* Has an omentum reaching down to the os pubis, and why, *ib.* From his posture is not liable to herniae, 348. Difference between the shape of his stomach and that of man, 348. His intestines much shorter in proportion than the human, 349. Duodenum, 350. Appendix vermiciformis, 351. Use of the mucous glands on its internal surface, *ib.* n. Colon described, 352. Rectum, *ib.* Two bags containing an intolerably fetid mucus near it, *ib.* Mesentery longer than in man, 352. Pancreas, spleen, and liver, described, 353. Kidneys, glandulae atrabiliariae, ureters, and bladder, 354. Spermatic vessels, 358. Scrotum, testicle, and

and penis, 359. Their manner of generation accounted for, 360. Prostate glands and uterus, *ib.* Diaphragm and mammae, 361. Sternum, Pericardium, and heart, 362. Thymus, 365. Thoracic duct and lungs, 366. Dogs proved to be carnivorous from the form of their teeth, 367. Tongue described, *ib.* Velum pendulum palati, 368. Oesophagus and nose, 369. Ear, *ib.* Eye, 370. Brain, 372. Olfactory nerves and organs of smelling, 373. Particular description of the muscles, 375. List of those peculiar to the animal, 392

Dropsties supposed to be occasioned by an increased secretion or impeded absorption, 244. Produced by tying the vena cava and jugular veins of dogs, 259. The dropfy in these cases probably owing to the rupture of lymphatic vessels, 259

Ductus arteriosus, a canal in children, but a ligament in adults, 130

Ductus venosus, a blood-veessel of the foetus carrying part of the blood to the vena cava, 31

Ductus aquosi, a name for the lymphatic vessels, from the supposed identity of lymph and water, 209

Dura mater affords a strong coat to the nerves, 271

## E.

Eagle, how enabled to look at the sun, 439

Eggs defined, 34. First appearance of the chick in incubation, 56. Particular history of the changes they undergo at that time, 418

Elasticity, whether the nerves perform their functions by means of it, 276  
Electrical fluid too much unknown to be applied to the phenomena of the animal economy, 287

Embryo, see foetus

Emulgent arteries, two large branches of the aorta going to the kidneys, 147

Encephalon, when irritated or compressed, occasions palsy in the nerves arising from the injured parts, 274. Probably secretes the nervous liquor, 286

Excretory ducts described, 91

Exhaling vessels described, 92

Explanation of plates, 203, 235, 330, 331

## F.

Face, course of the lymphatic vessels in it, 231

False water, collected between the chorion and amnion, or between the lamellae of the chorion, 25. Generally in small quantity, 26. May flow without injury to the woman at any time of pregnancy, 26

Fatness, how occasioned, 78

Female infant, peculiarities in its structure, 12

Fishes supposed to be destitute of a lymphatic system, 261. Divided into such as have lungs, and such as have not, 345. Their anatomy, 440. Their cuticle and cutis lie below their scales, *ib.* Some have a line on each side, which seems to answer the purpose of mucous glands, 161. How they swim, *ib.* Have no neck, 441. Inside of their abdomen covered by a black coloured membrane, 441. Peculiar construction of their teeth, 441. Superfluous water taken in with their food, passes off by the bronchia, 441. Oesophagus very short, and scarce to be distinguished from the stomach, 442. Digestion performed in them by means of a menstruum, *ib.* Their pancreas resembles a multitude of small worms, 442. Some kinds of fishes have a pancreas resembling that of amphibia animals, *ib.* Peculiarity in the structure of the gall-bladder, 443. Hepatico-cystic ducts exist in fishes as well as other animals, *ib.* n. Spleen subject to the pressure of the air-bag, 443. Organs of generation, *ibid.* Swimming-bladder described, 445. Why dead fishes rise to the top of the water, *ib.* Why flat fishes lie at the bottom, *ib.* Kidneys, diaphragm, heart, and bronchia, 446. Their absorbent system, 447. Thoracic duct, 449. Brain, 450. Organ of smelling, *ib.* Their food probably discovered by means of it, 450. Experiment showing that they do not discover it by the eye, *ib.* Description of their eyes, 451. Their ear described, 451  
Fingers sometimes endowed with sensations like those of hearing and tasting, 294  
Fluids of the body, how restored, 77. Those moistening the cavities of the thorax

- thorax and abdomen, supposed to be mere water, 243.
- Foetus's position of it in the uterus, 31. Its peculiarities, 32. Supposed to exist in the mother, 41. Difficulty of accounting for its assuming the human or any other shape, 42. Probably does not increase for a long time, 43. Conjectures concerning the means of its growth, 44. Its first appearance is by first branched fœcilli, proceeding from the surface of the ovum, 45. Appears as a shapeless mass on the 17th day, *ib.* Has a very large head and slender body when the parts first begin to form, *ib.* Receives first a white liquor, and then red blood from the uterus, 46. Wrisberg's hypothesis concerning the nutrition of the foetus, 47. Instance of a human foetus which suffered no loss of blood, though the mother died of an effusion of the vital-fluid, 49. The foetus undoubtedly receives its nourishment from first to last by the umbilical vein, 51. Whether it receives any nourishment by the mouth also, 52. Few faeces collected 53. The bladder frequently almost empty, *ib.* The whole foetus originally a gelatinous matter, 54. Composed of a great quantity of water with little earth, 55. Its blood perfected from the fat, 55. Its vessels first appear, 56. Particularities of the primeval foetus, 56. The heart alone first begins to move, 57. Its force counteracted by the viscosity of the humours, *ib.* Its arteries lengthened by the force of the heart, 57. Increases in bulk very quickly, 58. Particular description of the foetus come to maturity, 61. How the circulation is performed, 31, 62. Thymus very large, 62. Cavity of the breast short, and liver very large, *ib.* Foetus does not respire *in utero*, 64. In some cases may possibly draw in air from the vagina of the mother, 65. Causes and manner of its birth, 66, 67. How the circulation is performed in the foetus of a cow, 398.
- Foramen ovale, why closed up after the birth of the infant, 72. Dispute concerning it, 398.
- Fowl's divided into those that feed on grain, and such as feed on flesh, 344, 405. Their anatomy, *ib.* Uses of their feathers, *ib.* The strongest muscles of their bodies inserted into their wings in order to fit them for flying, *ib.* In what manner they convey themselves through the air, 406. Curious mechanism of their toes, 407. Uses of this mechanism to various birds, 407. Of their beaks, 408. Why domestic fowls become lean when confined, 410. Peculiarities in their eyes, 433. Why they see ill in the dark, 434.
- Frogs have only one auricle and ventricle, with a single artery, 439.
- Functions explained by the hypothesis of a nervous fluid, 291.
- G.
- Galen, an obscure writer on anatomy, 334.
- Gall-bladder wanting in some animals, 354.
- Ganglions, a kind of knots on the nerves, 272. Have thicker and more numerous coats and larger blood-vessels than the nerves, with longitudinal fibres, *ib.* Conjectures concerning the uses of them, 301.
- Germ, see foetus.
- Glandula thyroidea abounds in lymphatic vessels, 232.
- Conjecture concerning its use, 365.
- Granivorous birds, 405.
- Growth of the body, by what means it takes place, 75. Heart increases less than any other part of the body, 75. At what time the growth ceases, 76. Fatness produced when the growth of the body ceases, 78.
- Goose, why it stretches out its neck in ascending, 407.
- H.
- Hardness of the whole body takes place in old age, 79.
- Heads of quadrupeds much lighter than they would seem, 372.
- Head and neck, description of their lymphatics, 230.
- Heart sometimes wanting in foetuses cannot prove the circulation in them to depend on the mother, 50. Is the only moveable and irritable part of the foetus, 56. Moves almost alone in the human embryo, 57. By what means its power is limited, 57. Its septum perforated in the foetus by the foramen ovale, 63. Increases less than any other part of the body, 75. Its proportion eight times less in proportion in the adult than in the

- the foetus, 76. Becomes less irritable by frequent contractions, *ib.* Becomes at last unable to propel the blood, 82. Its rest not an absolute sign of death, 83. Absorbents of the heart very numerous, 225.
- Heart and arteries. Effects of their action on the blood, 105.
- Hernia, a disease falsely supposed to be incident to quadrupeds, 358
- Hewson's account of the properties of the lymph, 243
- Hiccough, how occasioned, 321. A bad symptom in an inflammation of the liver, 321
- Hippocrates, his improvements in anatomy, 334
- Hippomanes described, 397
- I.
- Ilium has fewer lacteals than the jejunum, 220
- Impregnation, changes produced in the uterine system by it, 26
- Incubation, history of the changes produced by it, 413
- Injections, course of the chyle shown by them, 241. Experiments by their means to prove the doctrine of absorption by the red veins, inconclusive, 260
- Insects, a consideration of them useful to anatomists, 345. Have their bodies covered with an hard crust which serves for skin and bone at the same time, 452. Their various classes named from their legs and wings, 453. Curious structure of their eyes, *ib.* Whether they have any brain, *ib.* Of their stomach, heart, lungs, and manner of generation, 454. Some of them have no sex *ib.* Are not produced from putrefaction, 455. Their various changes, *ib.*
- K.
- Kidneys of a dog have a pelvis formed within their substance, 355. In the foetus of a cow are composed of different lobes, 400
- L.
- Lacteal sac and duct described, 226. Lacteal vessels discovered by Asellius, 206. So called from their colour, 219. Description of their course through the intestines, *ib.* From them through the mesentery to the spine, 220. Divided by the mesenteric glands into two regions, *ib.* Larger and more numerous in the jejunum, than the ilium, *ib.* Terminate at last in the thoracic duct, *ib.* Lap-dogs sometimes troubled with an epiplocele when very fat, 359
- Left-handed people, mistake concerning them, 364, n
- Life, by what means preserved, 75
- Liquor amnii, or waters surrounding the foetus, 25. Purest and most limpid during the first months of pregnancy, *ib.* Unfit for the nutrition of the foetus, tho' some of it may perhaps be absorbed, *ib.*
- Lithotomy, why the high operation of it can be performed in man only without danger of opening the cavity of the abdomen, 357
- Liver, why divided into a great number of lobes in dogs, cats, lions, &c. 353. Why formed of one entire piece in others, 354. Why it has no connecting ligament with the diaphragm in dogs, *ib.*
- Lizard, circulation of the blood in it, 439. See frog
- Lusus naturae of little consequence to be known, 337
- Lymph, of its properties, 243. At first supposed to be mere water, *ib.* Is coagulable by heat, and even by mere exposure to the air, 244. Its viscosity different in different animals, 245. Or in different states of the same animal, *ib.* 246. Difference between the coagulable lymph of the blood and of the lymphatic vessels, 245, 246, 247. Varies occasionally from a more viscid to a more watery state, 247. Lymph exhaled on surfaces differs widely from that exhaled into cavities, 249. Is probably changed into pus, 249. Of its secretion, 250. Discussion of the question, Whether the lymph is secreted by exhalant arteries, or transudes through inorganic pores, 251. Whether it is absorbed by the red veins, 255. Of its absorption by the lymphatic system, 264. Lymphatic glands discovered by Nuck, 207. Particular description of their situation and figure, 211
- Lymphatic vessels, when and by whom discovered, 207. Very early supposed to be absorbents, *ib.* Supposed by many anatomists to be merely continuations of arteries, *ib.* At first called *Ductus Aquosi*, from their being pellucid,

pellucid, 209. Their coats cannot be separated from one another, *ib.* Most of them open into the thoracic duct, *ib.* Are capable of being inflamed, 210. Are full of valves, *ib.* Lymphatic vessels of the lower extremities described, 212. Description of those of the trunk, 218. Discharge themselves into the thoracic duct, 220. Those of the spleen described, 221. Of the stomach, *ib.* Of the liver, 222. Different opinions of Dr Meckel and Dr Hewson concerning the lymphatics of the stomach, 223. Lymphatics of the lungs described, 224. Of the heart, 225. Bronchial lymphatic glands of the lungs, 230. Lymphatics of the head and neck described, 230. Of the upper extremities, 234. Those of the right side form four considerable trunks, 237. Termination of the lymphatics of this side, *ib.* Lymphatic vessels of birds described, 414

## M.

Man longer lived and more tender than most other animals, 81. Why he cannot fly like a bird, 406. Not originally a carnivorous animal, 350 Mathematics cannot be applied with any certainty to medicine, 338 Megrim, its symptoms and cure, 307 Membrana decidua described, 17. A lamella of the false chorion in immediate contact with the uterus, 23 Membrana decidua reflexa described, 24 Membrana nictitans, a membrane peculiar to the eyes of quadrupeds described, 370 Membranes may be formed from inspissated humours, 59 Menstrual flux, symptoms preceding it, 10. Proceeds from the vessels of the uterus, *ib.* The human species only subject to it, 11. Is not owing to the attraction of the moon, to acids, or ferments in the blood, *ib.* Has been known to break out through all the organs of the body, *ib.* Why more blood is derived at a certain time to the uterus and parts adjacent than before, 13. Particular account of the causes of this flux, 14. Why it is periodical, 15. Brutes in general have no menstrual flux, *ib.* Why it is wanting in men, *ib.* Suppression of the menses in pregnancy cannot

prove that the foetus is nourished by the menstrual blood, 48

Mesentery contains a vast number of lymphatic glands, 239

Milk produced from the chyle before it is assimilated with the blood, 241. Will be afforded by a woman for 12 hours after eating, though it has in that space circulated near 80,000 times through the body, 242

Monsters sometimes born without any organs of deglutition, 25

Muscular motion accounted for from the hypothesis of a nervous fluid, 297

Muscles accelerate the return of the blood by compressing the veins, 103. Their motion ceases soonest when the nerves, and latest when the veins, are tied, 284. Cease to act when their arteries are tied or cut, 299. No objection can thence be drawn against the existence of a nervous fluid, *ib.* Muscles of a dog, 391

Myology of brute animals useful to anatomists, 343. n

## N.

Nerves have little effect on the motion of the blood, 99. Treatise on them, 268. Proceed from the medullary substance of the encephalon and spinal marrow, 269. Uncertain whether they are propagated from that side on which they go out at the skull or the opposite one, 269. Composed of a vast number of parallel threads, 270. Conjecture concerning the diameter of one of the smallest nervous fibres, *ib.* Have a cellular coat from the tunica arachnoides, and another from the pia mater, *ib.* Are collected into tight firm cords by the dura mater, 271. Have numerous blood-vessels on their coats, *ib.* Are involved in a cellular substance, *ib.* Have little elasticity, *ib.* Divide into branches as they go off to different parts, *ib.* Unite in many places into one cord, 271. Their ganglions described, 272. Numerous small nerves sent out from the ganglions, *ib.* Lose their firm coats when sent to any of the organs of sensation, or to muscles, *ib.* Lose their sensibility when the parts become rigid, *ib.* Probably terminate without any confusion of the fibres, 273. Changes produced in their coats

coats may be a cause of nervous sympathy, *ib.* The sensations, motions, and nourishment of parts lost by the destruction of the nerves sent to these parts, *ib.* This happens likewise from an injury of the encephalon, 274. Or of the spinal marrow, 275. Objections to the nervous influence cannot be made from the examples of some creatures living without brains, *ib.* Supposition of the nerves acting by vibration, with the arguments for it, 276. Objections, *ib.* Arguments for their being hollow tubes, 278. Objections, 279. Answers to these objections, *ib.* The swelling of a nerve above a ligature cannot be an argument for or against this doctrine, 281. Decisive experiment in favour of a nervous fluid, 283. Objections to the conclusion from this experiment, *ib.* Answered, *ib.* Hypothesis of two different kinds of nerves *ib.* Discussion of the question, whether the nervous fluid moves with great celerity or not? 285. The nature of this liquor examined, 286. The liquor probably very thin, 287. Goes forward into the nerves in the same situation in which it is secreted, 288. Objections to this account of the nervous fluid, 288. Answered, *ib.* Why it is impossible that the nervous liquor can move with the velocity some have ascribed to it, 289. No probability of valves in the nerves, 290. Attempt to deduce the three great functions of nutrition, sensation, and muscular motion from the hypothesis of a nervous fluid, 290. Nutrition, how effected in this manner, *ib.* The opinion contradicted, *ib. n.* Nutrition by the nerves particularly considered, 291. No objection can be drawn from atrophies occasioned by the division of an artery, 292. Sensation and muscular motion accounted for, *ib.* Objections answered, 297. Particular nerves described, 302. The olfactory or first pair, 302. Singular contrivance for defending this pair from the pressure of the anterior lobes of the brain, 303. The optic or second pair described, 303. These two nerves decussate in some fishes, but not in man, 304. This opinion not perfectly just, *ib. n.* Third pair sent to the eye-balls, and

called *Motor Oculi*, 305. Fourth pair, or *nervi pathetici*, 306. Fifth pair divided into three great branches, *ib.* Ophthalmic nervi, the first branch, 306. Maxillaris superior, the second, 308. Maxillaris inferior, the third, 309. Sixth pair, *ib.* Arguments concerning the course of a nerve joined to this pair, 310. Seventh pair or auditory nerve, 312. Eighth pair, 313. Recurrent nerves, 314. Ninth pair, 315. Tenth pair, 316. Additional nerve of the sixth pair fully considered, 317. Spinal nerves, 319. First cervical pair, 319. Second cervical, 320. Third, *ib.* Fourth, 322. This pair divided into seven branches, *ib.* Dorsal nerves, 325. Lumbar nerves, 326. Obturator or posterior crural nerve, 327. Six pair of the false vertebrae, 328

Nutrition, particular account of it, 75  
Nymphae, their situation and use, 36

## O.

Obstructions in the small vessels, how prevented, 109

Old age occasions a rigidity of the whole body, 81. In what cases it comes on sooner, *ib.* Death happens but rarely from this cause alone, 82

Omentum, why longer in a dog than in the human species, 347

Ostii vaginae constrictor, tends to retard the reflux of the blood in the vagina, 37

Oviparous animals how hatched from the egg, 418. Whether the foetus receives nourishment by the navel, 424

Ovaria of women undergo some changes from pregnancy, 30. Contain a lymphatic fluid, 38. Some of their vesicles burst in a prolific copulation, *ib.* The foetus supposed to exist in them, 41

Ovum, its structure in early gestation, 16. Its size at different periods of pregnancy, 18. Particular account of the various changes it undergoes, 44, 45, 46, 50

## P.

Palsey sometimes produced on the side opposite to the injured part of the brain, 269

Pancreas asellii, a large gland in the mesentery of a dog, 352

Panniculus carnosus, one of the common teguments of quadrupeds, 346. Wanting in those of the porcine kind, *ib.*

- ib.* Why reckoned one of the teguments of the human body, *ib.* Particular description of that of a dog, 375  
 Penis, its lymphatic vessels, 274. May absorb venereal poison without our being aware of it, *ib.*  
 Pericardium, instance of its containing pus without any ulcer of the heart, 249  
 Peritoneum described, 61  
 Phthisical people have a serene and lively mind while their body decays, 83  
 Pitcairn, Dr. his erroneous calculation of the muscular force of the stomach, 338. n.  
 Piles, whence they arise in pregnant women, 104  
 Placenta appears at first a thick vascular part on the outside of the chorion, 16. Description of it in its perfect state, 21. Dangerous floodings occasioned by a particular formation of it, 22. Hemorrhages consequent on its extraction tend to prove an anastomosis of its vessels with those of the uterus, 49. How separated after delivery, 68  
 Pregnancy, signs of it, 27, 28  
 Pulmonary artery described, 111  
 Pulse, how occasioned, 87, 96, 99. Why a measure of the powers of the heart, 100. Slower in large than small animals, 101. Account of its quickness at different ages, 101. Why so quick after violent exercise, 103  
 Pupil of the eye differently figured in different animals, 371  
 Putrefaction, no cause of the heat of the blood, 108
- Q.**
- Quadrupeds, how divided, 344. General description of them, *ib.* In cold climates have warm thick furs, but not so in the more temperate, *ib.* Their cutis and cuticula disposed as in man, *ib.* Have a substance called *Panniculus Carnosus* under the cutis, *ib.* Most of them want clavicles, and why, *ib.* Adult quadrupeds resemble man in the disposition of their spermatic vessels, 358. Are not subject to herniae, *ib.* Have longer necks than the human species, 366. Why some of them have long jaws, 366. Have a peculiar membrane on their eye called *Membrana Nictitans*, 370, and a muscle called *Suspensorius*, 371.
- Have the brain much less in proportion than man, 372
- R.**
- Rabies canina, a disease peculiar to the dog kind, 347. n  
 Racemus vitellorum in birds, analogous to the ovaria of women, 417. Its motion during the time of coition, *ib.* How the egg is formed from it, *ib.*  
 Ravens endowed with an acute sense of smelling, 432  
 Receptaculum chyli, a name for the lower part of the thoracic duct, 223  
 Respiration of considerable efficacy in promoting the motion of the blood, 104  
 Retina described, 304  
 Right side, why stronger than the left, 364  
 Rummation of cows, &c. how performed  
 Runnet for curdling milk, how procured, 402
- S.**
- Scrotum, how the testicles are brought into it, 59. Less pendulous in dogs than in the human species, and why, 359  
 Semen of the male necessary to render eggs prolific, 34. Different animals impregnate the female eggs with it in various ways, 35. Produces the venereal desire, *ib.* How effused in the time of coition, 37  
 Serpent, circulation of its blood, 439  
 Serum of the blood sometimes of a white colour, 258  
 Sinus pulmonaris a name for the left auricle of the heart, 166  
 Sinus of the vena cava, a name for the right auricle, *ib.*  
 Sinus vena portarum, a name for the trunk of the vena portae hepatica, 192  
 Small animals have no distinction of sexes, 34  
 Spleen, its lymphatics, 221. Conjecture concerning its use, 443  
 Spinal marrow, injuries of it destroy the parts to which it sends nerves, 274. Probably secretes a thin liquor for the nerves, 286, 287  
 Stamina of young animals, whence they proceed, 40  
 Stomach, its lymphatics, 221, 223. Of a dog has thicker coats and a smaller contractile power than in man, 349
- Suspensorius,

Suspensorius, a muscle peculiar to the eyes of quadrupeds, 371

Symptoms of diseases, a great number of them supposed to be explained by the descriptions given of the nerves, 305, 307, 308, 309, 313, 315, 318, 321, 329, 330

Systole and diastrole of the arteries considered, 94. Effects of the systole on their contained fluids, 109

## T.

Tapetum of the eye differently coloured in different animals, and why, 371

Teeth increase in length when the pressure of the opposite ones is removed, 76

Thoracic duct described, 219, 223

Thymus described, 62. Large in the fetus, but decreases in the adult, *ib.* Proportionally larger in a dog than in man, 365. Conjectures concerning the use of it and the glandula thyroidea, *ib.*

Tortoise, anatomy of one, 436. Great strength of its shell, *ib.* Is without teeth, but the deficiency supplied by the hardness of its lips, *ib.* Circulation of its blood very different from that of other animals, *ib.* Description of its blood-vessels and absorbent system, 437

## U.

Umbilical arteries. See arteria umbilicales

Umbilical cord described, 21, 51. Caution to practitioners with regard to it, *ib.* Cannot be left open without danger of a fatal hemorrhage to the child, 68

Umbilical vein conveys nourishment to the fetus in utero, 51

Urachus described, 53. How closed up after birth, 74

Urine, causes of its excretion, 357

Uterine system, changes happening to it from impregnation, 26

Uterus of women resembles the breasts in its texture, 15. Of the gravid uterus, 16. Its contents in early gestation, 20. Its membranes, 23. Its size different in different women, 27. Changes occasioned by its gradual distension during pregnancy, *ib.* Changes at the same time produced in its appendages, 29. The uterus probably closed after conception, 40. Its state in the last months

of pregnancy, and after delivery, 65—68

Uvula wanting in dogs, 368. How this defect is supplied, *ib.*

## V.

Vagina described, 36.

Valvular lymphatic vessels, 310

Varices of the veins in pregnant women, whence they arise, 124

Vasa brevia, the name of the branches of the splenic artery going to the stomach, 144

Vasa deferentia in dogs have a stronger muscular power than in other animals, 369, n.

Veins sometimes a continuation of the arteries, 90. The facility with which the blood flows through them expedites its passage through the capillary arteries, 98. Of the veins in general, 161. Six large veins corresponding with the aorta and pulmonary artery, *ib.* Their structure more slender than that of the arteries, notwithstanding which they are stronger, 161, 162. Burst much more easily in living than in dead animals, 162. Are much larger than their corresponding arteries, *ib.* Have more numerous branches, *ib.* They run near the surface of the body, 163. Their valves how formed, *ib.* None of these to be found in the deep running veins of the viscera, 164. Sometimes originate from arteries and sometimes from smaller veins, 164. Pellucid veins, *ib.* Particular account of the different veins, 165. Veins of the head and neck, 170. Of the superior extremities, 177. Of the thorax, 181. Of the chylopoietic and assistant chylopoietic viscera, 186. Of the inferior extremities, 193. Of the pelvis, 197. On the back part of the abdomen and loins, 205. Of the absorption of lymph by the veins, 255.

Vena angularis, a branch of the external jugular running down the side of the nose, 171

Vena articulatis, a branch of the basilica coming from the muscles of the outside of the scapula, 178

Vena axillaris, the large vein formed by the union of all those of the arm and shoulder, 180

Vena azygo-, a branch of the superior cava

- Vena cava running on the right side of the vertebræ, 168, 183, 184.  
 Vena basilica, the principal vein of the arm, arising from the convex side of the carpus, 169, 177.  
 Vena bronchialis, the name of two small branches of the azygos, arising from the top of the aspera arteria and bronchia, 185.  
 Vena cæcalis, a branch of the mesafarica major, running from the beginning of the colon, 189.  
 Vena cava, the large vein in which all the others unite, and which carries the whole blood of the body to the heart, 165. Its general division, 166. Vena cava superior, 167. Inferior, 169. Situation of the extremity of its trunk, 200.  
 Vena cephalica, a small vein of the arm receiving the branches of the radial artery, communicating with the basilica, and terminating in the external jugular, 169, 177, 179.  
 Vena cephalica pollicis, branch of the former running between the thumb and metacarpus, 179.  
 Vena cervicalis, a branch of the external jugular coming from the vertebral muscles of the neck, 174.  
 Vena colica, a branch of the gastro-colica, coming from the middle of the colon, 190.  
 Vena colica dextra, another branch of the gastro-colica, coming from the upper part of the colon, *ib.*  
 Vena coronaria ventriculi, a vein surrounding the upper orifice of the stomach, 188.  
 Vena cubitalis externa, the name of the basilica while running along the ulna, 177.  
 Vena cubiti profunda, a branch of the mediana major of the arm, coming from the adjacent muscles, 180.  
 Vena demi-azygos, the common trunk of the left intercostals, 184.  
 Vena duodenalis, a branch of the gastro-epiploica dextra, 191.  
 Vena epiploica dextra, a branch of the mesafarica major, coming from the omentum, 189.  
 Vena epiploica sinistra, a branch of the splenic vein coming from the left side of the omentum, 188.  
 Vena frontalis, a branch of the jugularis externa anterior running down the forehead, 178.
- Vena gastro-colica, a branch of the great mesafaric vein formed by the union of the gastro-epiploica dextra and colica dextra, 190.  
 Vena gastro-epiploica dextra, a branch of the gastro-colica, coming from the stomach, pancreas, and omentum, 190.  
 Vena hæmorrhoidalis interna, or mesafarica minor, receives branches from many of the intestines, 186.  
 Vena hepatica brachii, a name formerly given to the basilica of the right arm.  
 Vena hypogastrica, or iliaca interna, receives the blood from the parts about the os sacrum, buttocks, and genitals, 198.  
 Vena iliaca communis, the great trunk formed by the union of the external and internal iliacs, 199.  
 Vena iliaca externa, the name of the crural vein after it gets from under the ligamentum Fallopii, 197.  
 Vena iliaca interna, the same with the hypogastrica, 198.  
 Vena intercostalis superior sinistra, a branch of the left subclavian, 169.  
 Vena intercostalis superior, another branch of the subclavian, coming from some of the intercostal muscles, 186.  
 Vena intestinalis, a branch of the vena portæ, coming from the intestinum duodenum, 191.  
 Vena jugularis externa anterior, a large vein of the neck, 170.  
 Vena jugularis externa posterior sine inferior, a large vein running down the side of the head, formed originally by the vena temporalis, 173.  
 Vena jugularis interna, a continuation of the lateral sinus of the brain, 175.  
 Vena mammaria externa, a branch of the axillaris, 180.  
 Vena mediana basilica, a branch of the vena basilica of the arm, 177.  
 Vena mediana cephalica, a branch of the cephalic vein of the arm, 179.  
 Vena mediana longa or major, the trunk formed by the union of the two foregoing, 180.  
 Vena mesafarica major, a large branch of the inferior vena porta, returning most of the blood from the superior mesenteric artery, 189.  
 Vena mesafarica minor, the same with the hæmorrhoidalis interna.

Vena

- Vena muscularis, a branch of the posterior jugular, coming from the muscles of the scapula and humerus, 174, 175
- Vena obturatrix, a branch of the hypogastrica coming from the obturator muscles and parts adjacent, 199
- Vena peronæa, a vein of the leg running up the inside of the fibula, 193
- Vena poplitea, the name of the trunk formed by the union of the tibialis anterior, posterior, and peronæa, 196
- Vena portæ, a large vein formed by the union of the splenic and mesenteric veins, &c. 191
- Vena preparata, the ancient name of the vena frontalis, 171
- Vena profunda, a branch of the basilica, 177
- Vena profunda brachii, or profunda superior, another branch of the basilica, 178
- Vena pulmonaris, the great vein by which all the blood is returned from the lungs to the heart, 165
- Vena radialis interna, a branch of the cephalic, 180.
- Vena salvatella, a vein of the back part of the hand ending in the basilica, 177
- Vena saphena major, returns the blood of the inside of the leg, 193
- Vena saphena minor, the vein returning the blood of the outside of the leg, 194
- Vena sciatica, the name of the crural nerve as it runs along the thigh, 197
- Vena splenica, a large branch of the vena portæ, receiving many of the veins of the stomach, pancreas and omentum, 187
- Vena subclaviana, the trunk formed by the veins of the head, neck and arms, 185
- Vena sub-humeralis, the same with the articularis, 178
- Vena super-humeralis, the same with the muscularis, 175
- Vena suralis, a branch of the tibialis posterior, coming from the gastrocnemii and soleus, 195
- Vena temporalis, the principal branch of the vena jugularis externa posterior, 173
- Vena tibialis anterior, a vein of the leg, 194
- Vena tibialis posterior, another vein of the leg, running up between the tibialis posticus and soleus, 195
- Vena vertebralis, a vein of the neck receiving the blood from the vertebral sinuses, &c. 176
- Venae cysticae gemellæ, the name of the veins running along the gall-bladder, 192
- Venae hepaticæ, branches of the vena cava dispersed through the liver, 170
- Venae intercostales, branches of the azygos and demi azygæ, 183, 184
- Venae intercostales superiores dextrae, bring back the blood from the first three series of intercostal muscles, 185
- Venae pancreaticæ, small branches of the splenica coming from the under edge of the pancreas, 188
- Venæ pectorales internæ, the common name of a number of small veins of the thorax, 181
- Venæ pudicæ externæ, branches of the erugal or sciatic nerve, coming from the musculus pectineus, parts of generation, &c. 197
- Venæ pudicæ internæ, branches of the hypogastric, coming from the parts of generation, 199
- Venæ raninæ, branches of the external jugular coming from the tongue, 172
- Venæ satellites arteriae brachialis, branches of the basilica, 178
- Venæ subclaviae, large branches of the vena cava lying under the clavicles, whence their name, 163
- Venereal buboes, how formed, 214
- Vesalius ill treated by other anatomists, 334
- Vesicula umbilicalis, a small bag between the amnion and chorion, seen only in the first months of pregnancy, 25
- Vesticles, the oldest parts of the body, 56
- Vibration said to be the manner in which the nerves act, 276
- Villus uscoat of the intestines absorbs the chyle by small holes in the villi, 238
- Vital power ought not to be used as an explanation of any of the phenomena of the animal economy, 108
- W.
- Waters. See liquor amnii
- Willis's anatoma cerebri has several pictures taken from brute animals, 344
- Women, more delicately formed than men,

men, 12. Have a larger pelvis, 13.  
The arteries belonging to it larger  
than in men, but the veins less, 12.  
Have naturally but one child at a  
birth, 67. Have but rarely three,  
and scarce ever five, 68  
Worms, their characters, 455. Their  
different orders, 456  
Wrinkles, how formed in old people,  
77

Y.  
Yolks found in female ovaries even  
without impregnation by the male  
semen, 41. Are appendages to the  
intestine of fowls, 42

Z.  
Zoophyta, a kind of compound ani-  
mals, 456.

## P R I N T S.

## DIRECTIONS to the Binder for placing the PLATES.

VOL. I. Table I.	to face page
II.	397
III.	400
IV.	403
V.	408
VI.	409
VII.	412
VIII.	415
VOL. II. Table IX. and X.	betwixt page 472 and Index
VOL. III. Tables XI. and XII.	betwixt page 204 and 205
XIII. and XIV.	betwixt page 232 and 233
XV. and XVI.	betwixt page 330 and 331

